POWER

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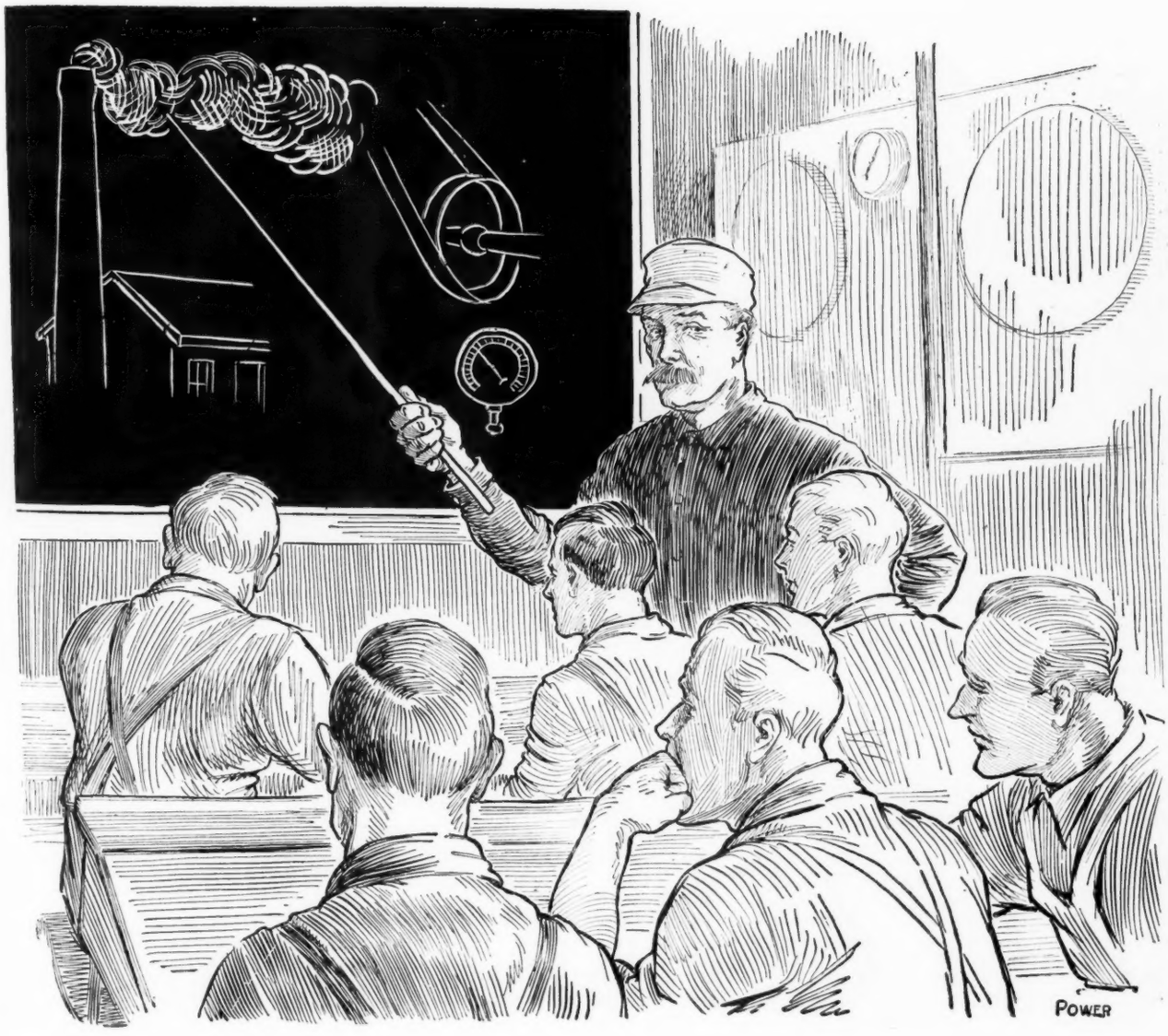
The Young Firemen's First Lesson



New Plant of The Pennsylvania Salt Manufacturing Company

Modern alternating-current plant with rotary-converter transformation to direct current for electrolytic work. Boiler room made prime factor in plant efficiency. Feature is operating board carrying most complete complement of instruments and control for boiler-room auxiliaries and dampers. The turbine room has interesting cooling system for generators and rotaries, and by means of a series of eductor-type jet condensers the auxiliaries are operated under varying vacuum to maintain the heat balance.

THE Pennsylvania Salt Manufacturing Company, located at Wyandotte, 12 miles from Detroit, Mich., has made an interesting addition to the power plant serving the works. Making caustic soda and bleaching powder by the electrolytic process requires a large amount of current and as it is a big item in the cost of production, efficiency is of more importance than in the average commercial power plant. For years the company has been operating direct-current generators driven by noncondensing Corliss engines, the exhaust steam being used partly in the manufacturing process and the remainder in low-pressure steam turbines. With the load increasing, a high-pressure turbo-generator was installed, and eventually plans were made for a new steam plant. The new plant, Fig. 1, was laid out specifically for convenience of operation, with plenty of room to make repairs and to allow for future extensions without disarranging the present layout. Although direct current is needed in the works, advantage was taken of the better economy obtained with high-speed alternating-current generating units, the transformation being effected by rotary converters. The boiler room, Fig. 2, has been made the prime factor in the plant. It has well-arranged modern equipment consisting of water-tube boilers, underfeed stokers and economizers. Control of all boiler-room auxiliaries is centered in an operating board, on which are also grouped a variety of instruments, indicating and recording, giving all information necessary for the efficient operation of the plant. The board is located in front of the boilers. In the turbine room generous use is made of gages; there is an interesting air washing and cooling system for the generators and an innovation is the use of a series of eductor-type jet condensers on the auxiliaries to maintain the heat balance. The vacuum does not exceed 10 in. The number of condensers used may be varied and with the auxiliaries there is choice between motor and turbine drive, so that the largest possible use may be made of the exhaust steam at all times. The present capacity of the new generator plant is 6250 kw. in two units, and the boilers have an aggregate rating of 2032 horsepower. Fig. 4 shows the general layout of the new steam plant. Fig. 6 is a transverse section through the plant.

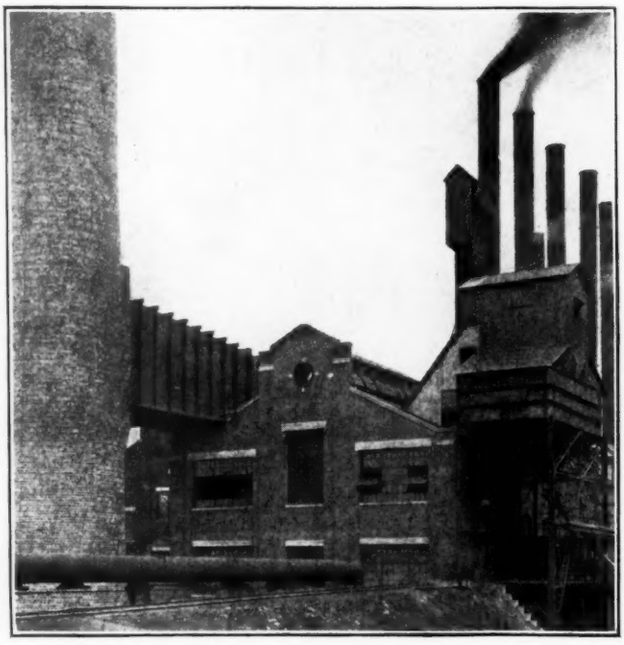


FIG. 1. EXTERIOR VIEW OF THE NEW PLANT

In the older boiler plant 300-hp. water-tube boilers equipped with side-feed stokers are set in batteries of two, each battery being served by a steel stack. The operating pressure is 160 lb. gage. In the new plant four boilers, each rated at 508 hp., are set two to a battery. The operating pressure will be 200 lb. at the turbine throttle, or about 210 lb. in the boiler, and the superheat 75 deg. The boilers are vertically baffled for three passes and the gas outlet is at the rear. Each battery of two boilers is served by an individual high-pressure staggered-pipe economizer containing 40 sections of 10 tubes each. The tubes are 9 ft. long, 4 in. diameter and in the aggregate provide 4968 sq.ft. of heating surface, which is slightly less than one-half of the steam-making surface in the boilers served. Each economizer has a water capacity of 25,200 lb. and is arranged for four-section group circulation countercurrent to the gas flow. Soot blowers are used in preference to scrapers, and from a pit underneath the soot is removed and discharged to the blowoff sewer by a vacuum steam-jet conveyor.

The boiler breechings pass directly back to a U-shaped flue under the economizer. On one side it incases the economizer inlet and on the other side continues past the outlet to the smoke flue on the boiler-room roof. A horizontal chain-controlled damper in each vertical leg and a vertical damper at the economizer outlet direct the flow of gases either through the economizer or up the bypass. The vertical damper and a damper in each boiler breeching are controlled mechanically from the operating board by handwheel, chain, sprocket and cable connections. In near proximity to the handwheels are the draft gages and thermometers showing

gas temperatures. There is a recording thermometer for the smoke flue on the roof, and in each breeching and at the outlet of each economizer are thermocouples, the instrument of the pyrometer and a multiple switch being located on the operating board.

On the roof the smoke flue is of tapering section, having an 8 x 20-ft. opening into the stack. The latter, built of radial brick, is 300 ft. high and 13 ft. diameter at the top. It was designed to provide for large increase in capacity. The main smoke flue is lined on the sides and bottom with hollow brick filled with insulation and the top with 2 in. of fire felt insulation. This same material 1½ in. thick has been applied to the boiler breechings and the economizer flues. Throughout an inner coating of asbestos cement is used.

Seven-retort underfeed stokers serve each boiler. The two stokers of each battery are driven by a 7½-hp. variable-speed direct-current motor under rheostat control from the operating board. A silent-chain drive connects the motor and the stoker shaft for the battery. From the latter individual chain drives run to each stoker. The two units are independent and each may be varied through a wide range of speed.

Forced draft is supplied by three multivane double-wheel fans direct-connected to 40-hp. direct-current variable-speed motors with rheostat control at the operating board. Normally, each fan serves a battery of boilers and the third fan is a reserve unit. The individual rated capacity is 25,000 cu.ft. of air per minute under a static pressure of 5½ inches. The fans take the heated air from the generators and deliver it to the main air duct from which damper-controlled flues lead to the individual stokers. It is the intention to operate the fans at constant speed and therefore constant pressure, the quantity of air admitted to each fuel bed being regulated by the dampers. The latter are mechanically controlled from the operating board. The starting rheostats for the motors are also located here and with them are ammeters on the board to show the load on each motor. A balanced system of draft is employed, the fans operating at sufficient pressure to overcome the resistance through the fuel bed, while the stack draws the gases through the boiler, economizer and the connecting flues.

Coal for the plant is delivered on a trestle at the side of the boiler room and, if the cars are of the bottom-dump type, is discharged into a track hopper. From the flat-bottom gondola, coal is unloaded by a locomotive crane into side pockets running down to the crusher. The latter is of the single-roll type driven by a 30-hp. direct-current motor. The coal is either crushed or bypassed around the crusher to a bucket elevator, driven by a 10-hp. motor, discharging upon a 24-in. shuttle belt mounted on a carriage, traveling on rails over the bunker. The carriage can be moved to the desired location by a motor-operated winch. The belt may travel in either direction and is driven by a 5-hp. motor. All conveyor motors are of the induction type. The capacity of the system is 60 tons per hour.

At the transfer point between the bucket elevator and the shuttle belt a sampling drum takes a certain percentage of the coal, delivering it to a No. 00 rotary fine crusher. This device delivers a definite percentage of the amount received to a sampling bottle, crushed and ready for an analysis.

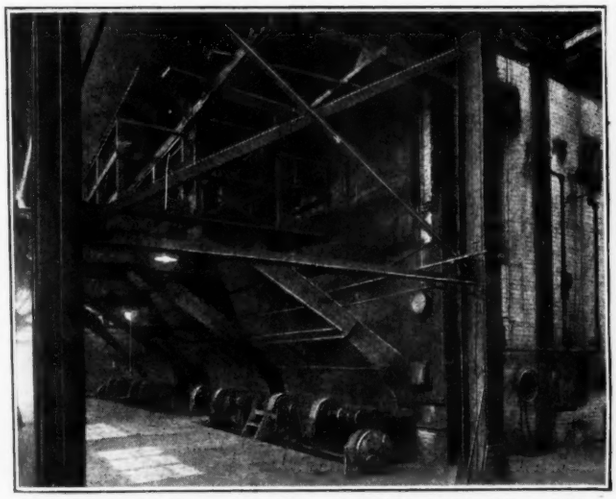


FIG. 2. BOILER FRONTS, SHOWING BUNKER, COAL SCALES AND STOKERS

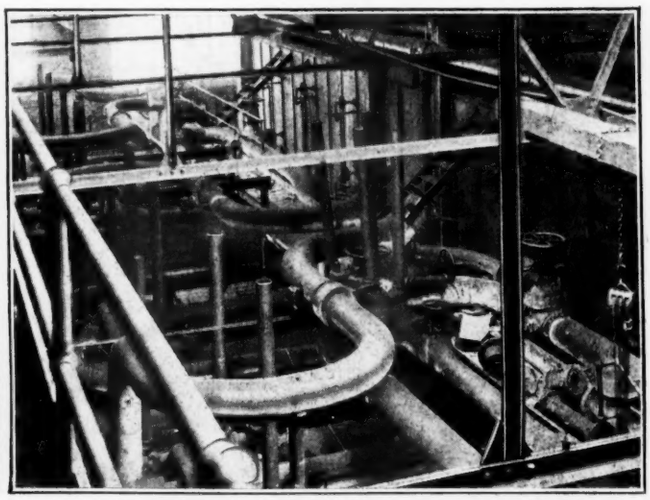


FIG. 3. PIPING OVER BOILERS AND ECONOMIZERS AT THE RIGHT

From the bunker the coal passes through 100-lb. traveling scales one to each boiler, to receiving hoppers delivering to chutes flared to the width of the stoker hopper. Registers are located on the scales and duplicate counters, electrically operated, on the operating board.

In line with recent practice the ashes are handled separately. From steel hoppers under the stokers, they are dropped through hand-operated gates into side-dump cars. From the latter the ashes are transferred to a skip hoist and automatically dumped into a 5000-cu.ft. hopper over the coal spur, from which delivery may be made directly to the railway cars, or through a swinging chute to trucks. The hoist is operated by a 10-hp. motor under push-button control. A track scales permits weighing the ashes while in the side-dump cars.

For boiler feeding there is a multiplicity of supply. Water can be drawn from the purification system of the older plant, from the hotwell of the new plant, from these two sources simultaneously, or from the water system serving the plant. The new method recently designed to conserve the economizer by not subjecting it to boiler pressure, has been adopted. Low-pressure pumps pass the boiler feed through the

economizer at a pressure of 60 lb. into the suction of the high-pressure boiler-feed pumps, capable of delivering to the boilers against the pressure head of 210 lb. Regulators control the flow. The piping is arranged so that the low-pressure pumps may deliver into the suction of the high-pressure pumps, bypassing the economizers, or the high-pressure pumps may do the entire work, taking their suction from the usual source and delivering the water through the economizers to the boilers. The economizers being of the high-pressure type, will withstand this service.

For the low-pressure pumping there are two 4-in. single-stage double-suction centrifugal pumps driven at 1800 r.p.m. by 20-hp. induction motors. Normally these pumps take water from a line joining the hotwell with the storage tank of the water-purification system of the older plant. As the connection is open the same water levels exist in either source. As the pump connection is much nearer the hotwell, the tendency is to draw primarily from here, but as the water level drops in the hotwell, makeup water from the purification system automatically flows in to make up the shortage.

Each of the two high-pressure centrifugal pumps can deliver 250 gal. of water per minute at a temperature of 260 deg. against a head of 485 ft. One is a 3-in. five-stage pump direct-connected to a 60-hp. induction motor having a speed of 1800 revolutions per minute. The other is a 3-in. three-stage pump driven at 3000 r.p.m. by a 60-hp. velocity-stage turbine. Either has sufficient capacity to supply the four boilers.

Main and auxiliary feed lines have been so interconnected that any boiler may be supplied from either main. For example, while three of the boilers are fed from the main feed line, the fourth may be under test, drawing its supply of water from the auxiliary main. A reciprocating boiler-feed pump receiving its supply from a calibrated tank has been installed for testing purposes. In the main feed line there is a venturi tube with a manometer and also a flow meter to measure the feed water, the instruments being located on the operating board. On the board there is also a steam-flow meter for each boiler. The latter instruments show the output in each case, and the aggregate readings may be checked against the total input shown by the water meters in the supply line.

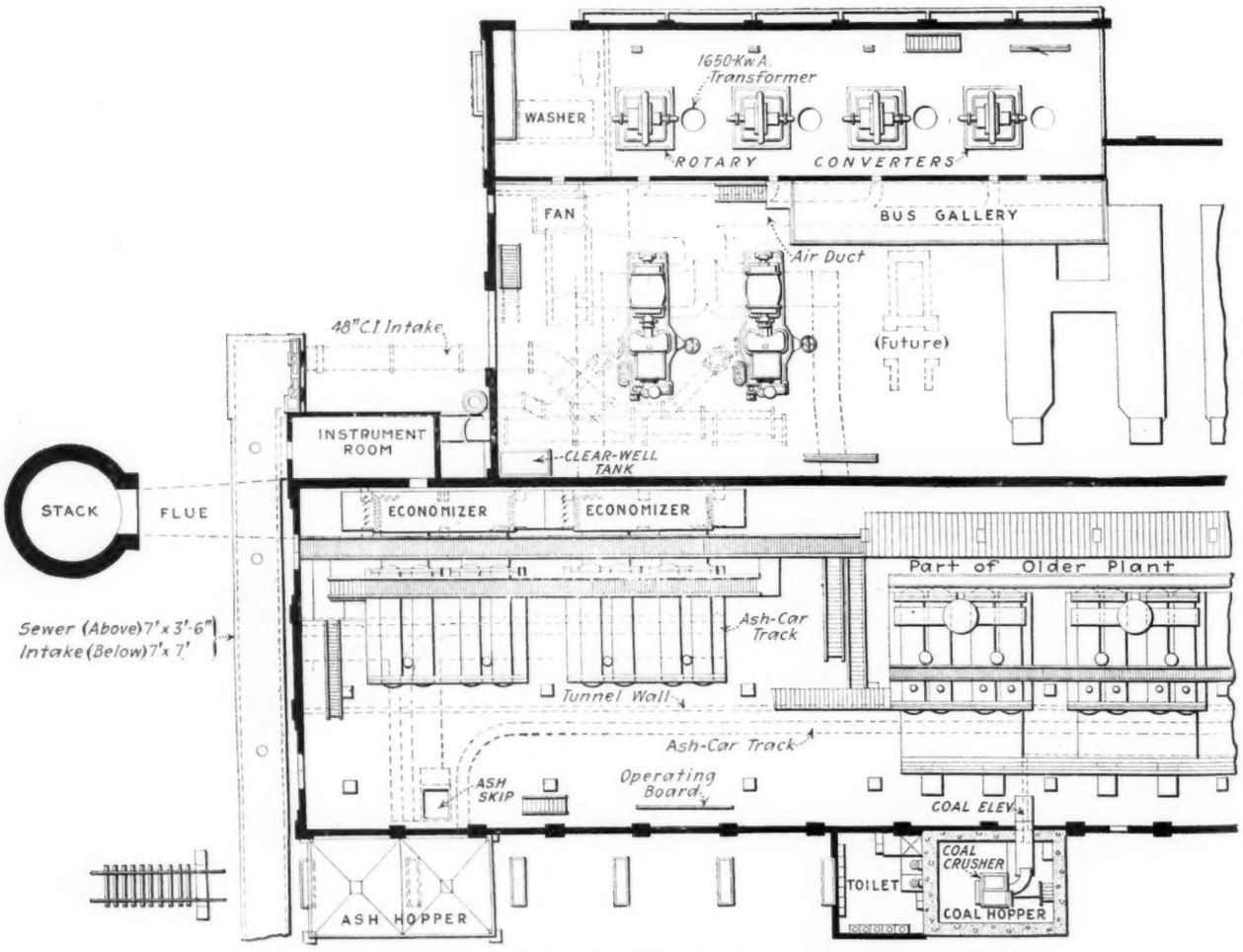


FIG. 4. SHOWING THE GENERAL LAYOUT OF THE NEW STEAM PLANT

From Fig. 5 it will be seen that in the high-pressure piping long-radius bends are the rule. Each battery of two boilers is designed to supply one of the turbo-generators. In other words, each rated boiler horsepower, or 10 sq.ft. of heating surface will care for approximately 3 kw. of generating capacity. There is connection between the two batteries and also to the main and auxiliary headers of the older plant. The lines are extra-heavy steel piping with lap or Van Stone joints and extra-heavy cast-steel fittings and valves. The piping over the boilers and the economizers is shown in Fig. 3.

A feature of the boiler room is the operating board, Fig. 8, on which are mounted an unusually complete complement of instruments giving the full data needed for efficient operation. As will be inferred from previous mention, control of the various boiler-room auxiliaries and of the dampers is also centered here and the board is out in front of the boilers in the most convenient place for the operators. It consists of six panels made of ebony asbestos wood and mounted on angle-iron frames. There is a panel for each boiler, containing the handwheels controlling the dampers in the breeching and in the forced-draft inlets, a steam-flow meter and draft gages showing the draft over the fire and in the last pass of the boiler and the pressure under the stokers. The fifth panel contains the flow meter on the feed water, the pyrometer and multiple switch previously mentioned, draft gages showing the draft on the stack side of the economizers and the handwheels for controlling the vertical dampers at the economizer outlets. On the sixth panel there are two large dial gages to give the pressures at the turbine throttles. They are calibrated to read from 195 to 225 lb. gage. In addition there are the three field rheostats and ammeters for the forced-draft fans and the two for the

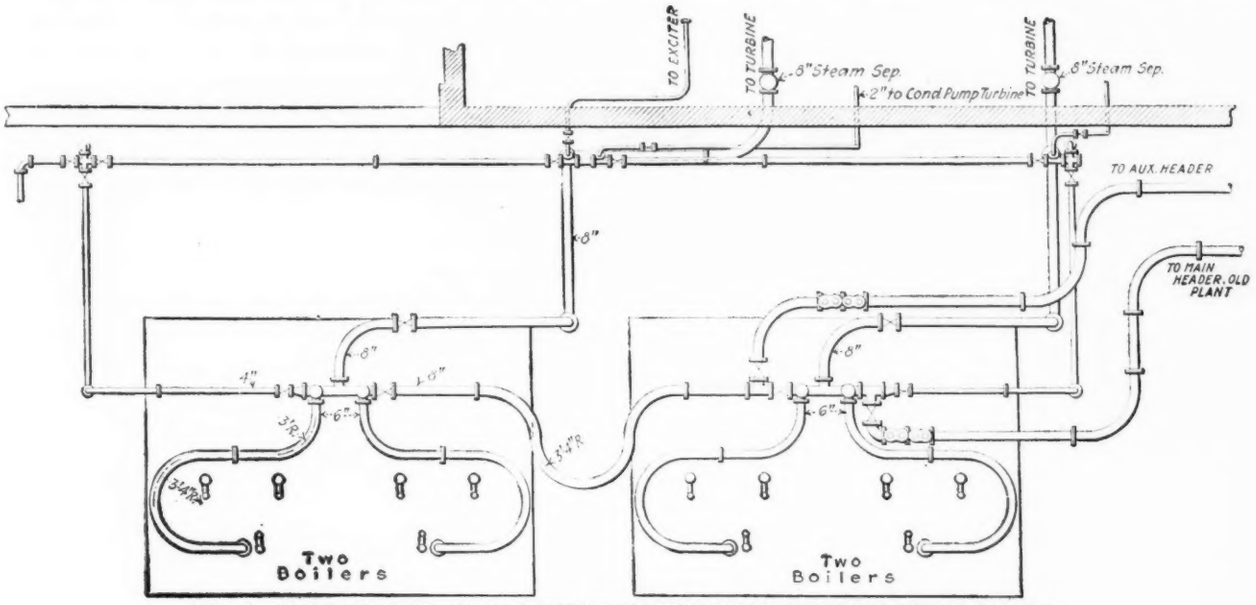


FIG. 5. SHOWING THE ARRANGEMENT OF THE HIGH-PRESSURE STEAM PIPING

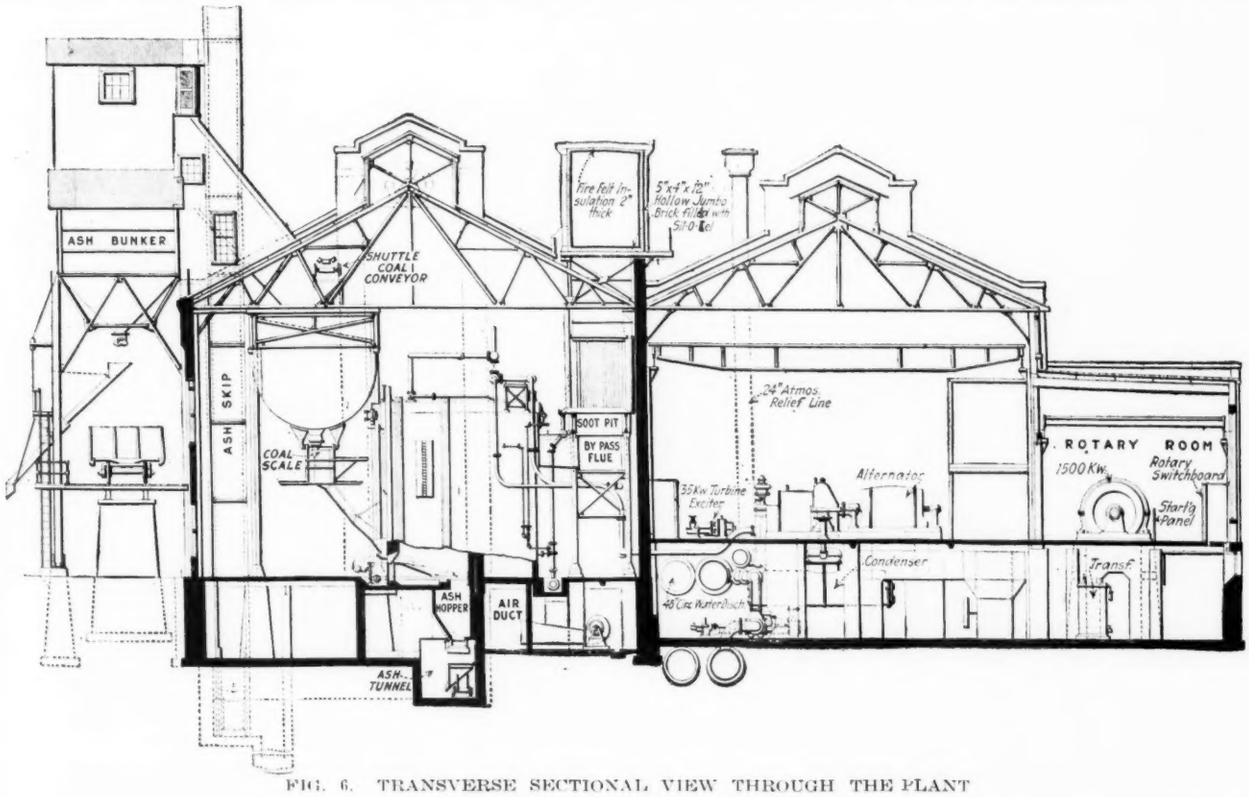


FIG. 6. TRANSVERSE SECTIONAL VIEW THROUGH THE PLANT

stoker motors. The main cutout switches and the starting rheostats for each of these five motors are located on the bottom sections of the boiler and economizer panels.

At the side of the operating board there is a recording gage panel containing four pressure-recording gages. Two have been connected to give the pressure at the turbine throttles and the other two record the pressure on the feed-water system, one being attached

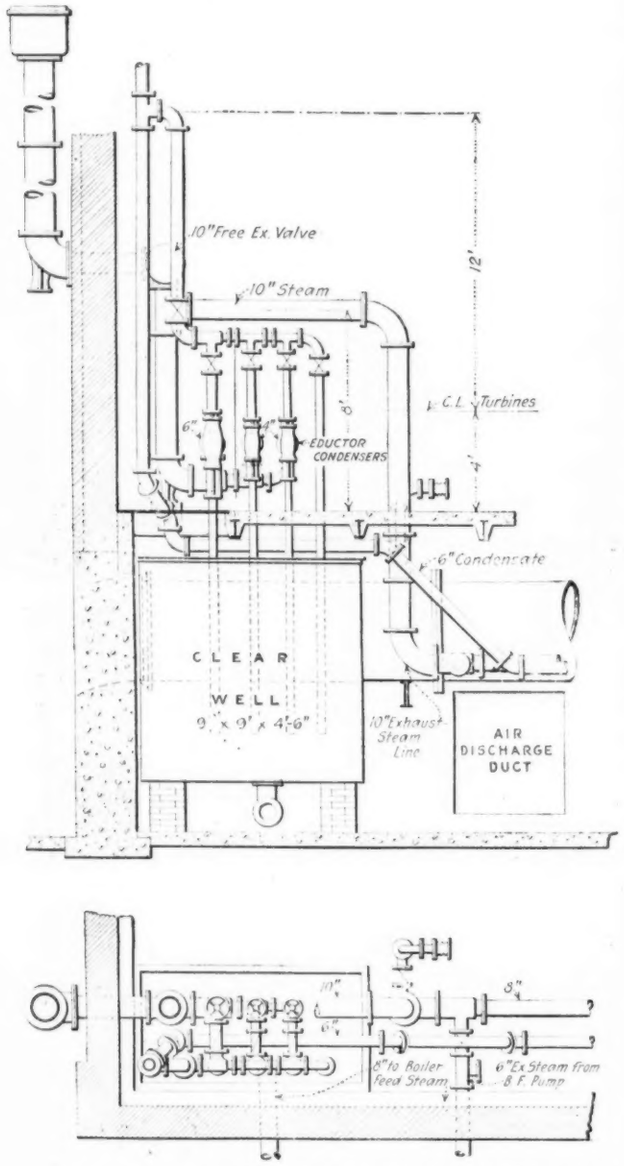


FIG. 7. ARRANGEMENT OF EDUCTOR CONDENSERS

to the system before the economizers and the other showing the pressure at the delivery to the boilers. A recording thermometer charts the temperature of the water entering the boilers and another the temperature of the water entering the economizers. Each battery is served by a CO_2 recorder, so piped that readings may be obtained from the individual boilers. The plant is also provided with a hand Orsat.

The installation of the instruments previously enumerated is the first step toward efficient operation. The second is the maintenance of a testing department that makes all minor repairs to steam and electrical instruments, keeps the instruments in good working order and checks them with standards to insure accuracy. The third will be the careful analysis and interpretation of the records obtained looking toward maximum economy. Recognition of the first two factors speaks well for the plant under description and indicates that the third factor will be given intelligent and thorough attention.

In the turbine room, Fig. 9, there are at present two main units with individual ratings of 3125 kv.-a., which, with 100 per cent. power factor made possible by the use of synchronous rotary converters, means that many kilowatts. The turbines are of the double-flow type and when operating under 200 lb. steam pressure, 100 deg. superheat and 28.5 in. of vacuum, are guaranteed to develop at full load a kilowatt-hour on 14.2 lb. of steam. The generators are three-phase, 2300-volt, 60-cycle machines, the speed being 3600 revolutions per minute. There is plenty of room around the machines and at the side of each are large openings covered with iron grating to supply light and ventilation to the basement and to provide for the removal of the condensing apparatus.

The surface condensers serving the main units are of the unit type, with the circulating, air and condensate pumps on one shaft driven through reduction gearing by a 66-hp. turbine, the speed reduction being from 5400 to 1150 revolutions per minute. Each condenser has 4250 sq.ft. of surface, or about 1¼ sq.ft. per kilowatt of rating. The condensation guarantee is 40,000 lb. of steam per hour, with 2,000,000 lb. of 65-deg. water, a ratio of 1 to 50.

In order that the condenser may be cleaned or repaired without shutting down the unit, a back-outlet gate valve with bevel gears and operating stand with handwheel on the main floor has been inserted between the turbine and the condenser. Closing the valve discharges the exhaust steam into a 24-in. atmospheric relief line.

Cooling water from the Detroit River is conducted to the building in a concrete duct 7 ft. square and is distributed to the condensers through a 48-in. cast-iron pipe running under the basement floor. As the pump suction is about 30 in. below the minimum low-water level in the river, there should be no priming difficulties. At the entrance of the intake stationary screens in duplicate have been provided. They are raised for cleaning by a hand-operated hoist. Iron gates moving vertically in slides and operated by bevel-gear stands are provided at the inlet and at the junction between the concrete duct and the cast-iron pipe. The discharge water from each condenser passes through a 16-in. pipe into a 48-in. line emptying into a 3 x 7-ft. concrete sewer running on top of the intake to a point near the shore, where it is deflected down stream.

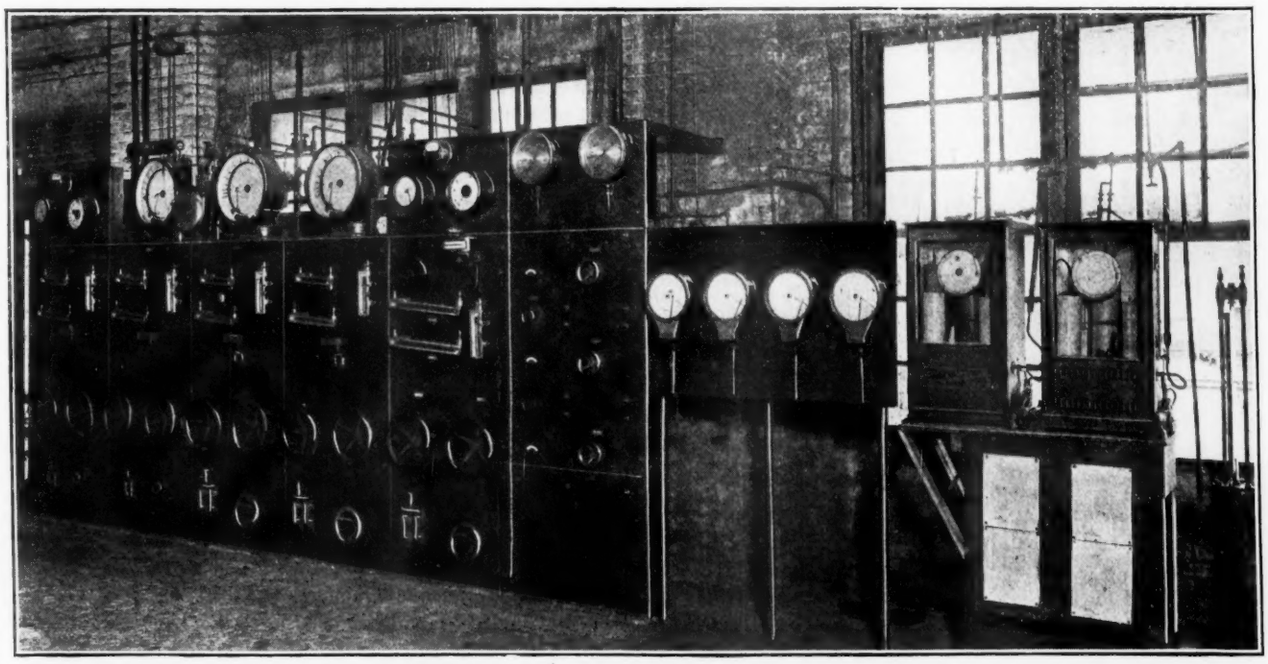
The basement is below the river level, and all drainage is collected in a sump and raised to the sewer by a motor-driven submerged centrifugal pump, a steam pulsometer or a siphon.

A unique feature of the plant is the use of three eductor-type jet condensers, Fig. 7, taking the exhaust steam from the auxiliaries and the condensate from the main condensers. The latter, at a temperature approximating 90 deg., is forced through the jet condensers where its temperature is raised by the

auxiliary exhaust to that most economical for the economizer, probably 150 deg. The sizes and capacities of the three jet condensers are: 6-in., 120 gal. per min.; 4-in., 90 gal. per min., and 4-in., 80 gal. per minute. They are connected in parallel and depending upon the requirements one, two or all three may be operated, or the condensate may be bypassed directly to the hotwell. As the auxiliaries are driven partly by turbine and partly by motor, there is opportunity to vary the exhaust steam to suit the demands.

The condenser auxiliaries are turbine-driven, as are also one of the two boiler-feed pumps and one of the two exciter units. When the two main turbines are running at full load and the steam auxiliaries are in use, it is estimated that the three jet condensers will raise the temperature of the condensate to 175 deg. Under average operation the vacuum on the auxiliaries will not exceed 10 inches.

To insure pure water for the turbine glands, condensate is used. The discharge line was carried to a point 12 ft. above the center line of the turbine to insure a minimum of 5 lb. pressure on the glands and was then extended sufficiently to insure a minimum head of 30 ft. required by the jet condensers. To protect the condensate pump the line is open at the top and an overflow is provided. The condensate and exhaust-steam lines are so piped and valved that a test can be run on either main unit or any auxiliary unit without



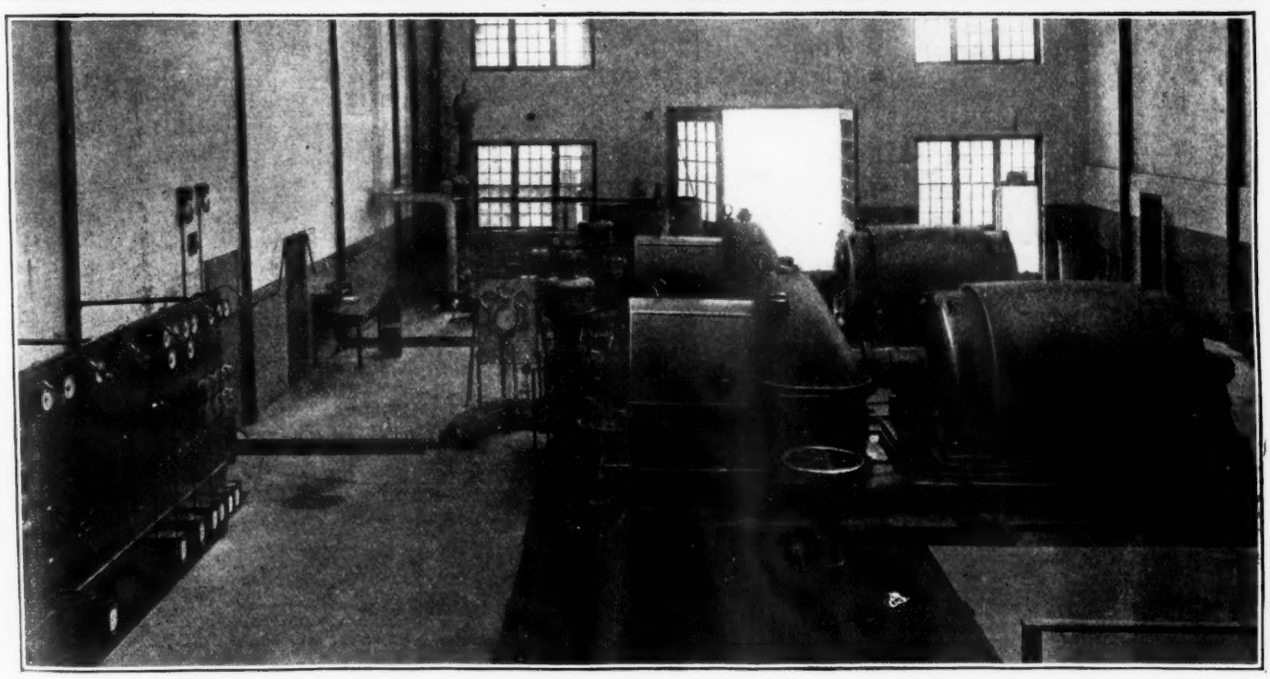


FIG. 8. TOP VIEW. OPERATING BOARD IN BOILER ROOM. FIG. 9. BOTTOM VIEW. THE TWO TURBO-GENERATOR UNITS

disturbing the piping. With testing in view the water-sealed turbine glands also have connection to a separate circulating system.

As in the boiler room there is generous use of instruments. To the outlet of each turbine after the last row of blading recording thermometers have been connected. Opposite the temperature readings on the

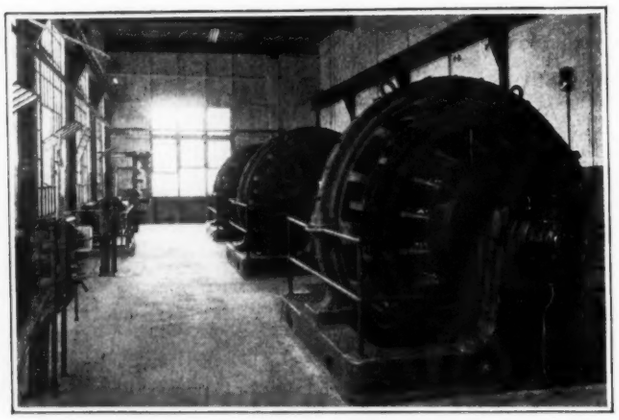


FIG. 10. ROTARY CONVERTER ROOM

charts are the corresponding vacua in inches of mercury. At the throttles are indicating thermometers giving temperatures and the corresponding pressures. There are also indicating gages to show pressures at the throttle and at the primary inlet, and plates on the casings of the turbines have been provided for gages to show the pressure at the secondary valve and the pressure between the impulse and reaction elements of the turbine. By reading the pressure gage at the throttle and then referring to the double-scale thermometer, it is an easy matter to determine the superheat, as it is the difference between the temperature existing and that corresponding to the pressure. On the condenser circulating water there is a two-pen recorder, one pen recording the inlet temperature and the other the temperature of the discharge.

Other electrical equipment in the station in addition to the main generators are the two compound-wound exciters. One is a 45-kw. machine driven at 1200 r.p.m. by an induction motor. The other is a 35-kw. exciter having the same speed. It is driven by a steam turbine through a reduction gear having a ratio of 6 to 1.

The alternating-current bus structure is mounted on a concrete platform 10 ft. above the main floor. It is 11 ft. wide and 50 ft. long, having space for future extensions. The structure contains the oil circuit-breakers, electrically controlled from the main switchboard on top of the inclosure, and the double bus system. Current is fed out from the board at 2300 volts, with transformers at points of service. There is one set of 2300-440-volt transformers for the boiler room, one for the turbine room exclusive of the turbine-driven exciter, which has its own transformer, and one for each of the rotary converters.

Of the four rotary converters planned three of the commutating pole type, starting from the direct-current side, are now installed, Fig. 10. Each is rated at 1500 kw., the speed being 450 revolutions per minute. On the shunt-wound direct-current side the voltage is 250. The alternating-current end is 60-cycle six-phase

PRINCIPAL EQUIPMENT OF WYANDOTTE PLANT OF PENNSYLVANIA SALT MANUFACTURING CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Water-tube	5,087 sq.ft.	Generate steam	210 lb. press., 75 deg. superht.	Babcock & Wilcox Co.
4	Stokers	Underfeed	7-retort	Serve boilers	Driven by var.-sp. motors	Sanford Riley Stoker Co.
3	Fans	Double-wheel multi-vane	25,000 cu.ft. per min.	Forced draft	Driven by 40-hp. d.c. motor, variable speed	B. F. Sturtevant Co.
1	Stack	Radial brick	300 x 13 ft	Serve boilers		H. R. Heinicke, Inc.
2	Economizers	High-pressure	4,968 sq.ft.	Heat feed water	4-section group circulation	B. F. Sturtevant Co.
1	Conveyor	Steam-jet	4 in. diam.	Remove soot from economizer		American Steam Conveyor Corp.
2	Pumps	Single-stage cent.	4-in.	Feed water to economizers	Dr. by 20-hp. G. E. ind. motor	De Laval Steam Turbine Co.
1	Pump	Five-stage cent.	3-in.	Feed water to boilers	Dr. by 60-hp. a.c. ind. motor	Allis-Chalmers Mfg. Co.
1	Pump	Three-stage cent.	3-in.	Feed water to boilers	Dr. by 60-hp. turbine	De Laval Steam Turbine Co.
1	Coal crusher	Single-roll	50 tons per hr.	Crush coal for stokers	Dr. by 30-hp., d.c. Fairbanks-Morse motor	Jeffrey Mfg. Co.
1	Bucket elevator		60 tons per hr.	Elevate coal above bunker	Dr. by 10-hp. Mechanical Appliance motor	Webster Mfg. Co.
1	Shuttle belt		24-in.	Deliver coal to bunkers	Motor-driven	Webster Mfg. Co.
1	Coal crusher	Rotary fine	No. 00	Crush coal samples		Sturtevant Mill Co.
4	Coal scales	Dumping	100-lb.	Weigh coal to boilers	Traveling	Richardson Scale Co.
1	Ash car	Side-dump	21-cu.ft.	Receive ashes from stoker hoppers		
1	Skip hoist		1-cu.yd. bucket	Raise ashes to storage tank	Dr. by 10-hp. M.A. motor, Cutler-Hammer control	Webster Mfg. Co.
2	Turbines	Double-flow	3,125-kw.	Main generating unit	200-lb. press., 75 deg. superheat, 7600 r.p.m.	Westinghouse Elec. & Mfg. Co.
2	Generators	3-phase, 60-cycle	3,125-kw.	Main generating unit	2300 v., 100 per cent p.f., 3600 r.p.m.	Westinghouse Elec. & Mfg. Co.
2	Condensers	Surface	4,250-sq.ft.	Serve turbines	Unit type	Westinghouse Elec. & Mfg. Co.
2	Pumps	Centrifugal		Condenser circulating water	Dr. by Westinghouse turbine and reduc. gear, 1150 r.p.m	Westinghouse Elec. & Mfg. Co.
2	Pumps	Centrifugal		Condenser air	Dr. by Westinghouse turbine and reduc. gear, 1150 r.p.m.	Westinghouse Elec. & Mfg. Co.
2	Pumps	Centrifugal		Condenser condensate	Dr. by Westinghouse turbine and reduc. gear, 1150 r.p.m.	Westinghouse Elec. & Mfg. Co.
3	Condensers	Eductor-type jet	120, 90 and 80 g.p.m.	Serve auxiliaries	Connected in parallel	Schutte & Koerting Co.
1	Exciter	Compound-wound	45-kw.	Excitation main units	Dr. by ind. motor, 1200 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Exciter	Compound-wound	35-kw.	Excitation main units	Turbine and reduc. gear., 7200-1200 r.p.m.	Westinghouse Elec. & Mfg. Co.
4	Rotary converters	Commutating-pole type	1,500-kw.	Transform a.-c. to d.-c.	Six-phase diametral, 250 v., d.c., 450 r.p.m.	Westinghouse Elec. & Mfg. Co.
4	Transformers	Oil ins., water-cooled	1,650-kv.-a.	Serve rotaries	Prim., 3-phase delta; sec. 6-phase diametral	Westinghouse Elec. & Mfg. Co.
1	Pump	Centrifugal	3-in.	Transformer cooling water	Dr. by 5-hp. ind. motor, 1800 r.p.m.	Buffalo Steam Pump Co.
1	Crane	Traveling, hand op.	10-ton	Serve rotary and trans. rm.		Cleveland Crane & Eng. Co.
1	Crane	Traveling, elec. op.	10-ton, 3-motor	Serve turbine room	Operated from cab	Shepherd Elec. Crane & Hoist Co.
1	Air washer	Water-spray	63,000 cu.ft. per min.	Wash generator cooling air		American Blower Co.
1	Fan	"Sirocco"	60,000 cu.ft. per min.	Air for generator cooling	Dr. by 30-hp. G.E. ind. motor, 1800 r.p.m.	American Blower Co.
1	Pump	Centrifugal	4-in.	Water for air washer	Dr. by 10-hp. ind. G.E. motor	Buffalo Steam Pump Co.
1	Pump	Reciprocating	14 x 8 x 24-in.	For boiler testing	Suction from calibrated tank	Manistee Iron Works Co.

Vulcan soot blowers for boilers and economizers, Ellison draft gages, one Republic steam-flow and one water meter, 3 G. E. steam-flow meters, Copes feed-water regulators, one Sturtevant No. 00 rotary fine mill, two Precision CO_2 recorders, Bristol recording instruments, Ashton, Asheroft and National indicating gages, Westinghouse switchboard, Crane valves, Vance steam traps, Simplex blow-off valves.

diametral. Guaranteed efficiency at full load is 95.7 per cent.

Each machine is served by a 1650-kv.-a. three-phase 60-cycle oil-insulated water-cooled transformer, delta-connected on the 2300-volt primary side and six-phase diametral on the secondary. Each transformer is mounted on a truck which may travel on a track in the basement under the rotary converters. An opening in the operating floor above each transformer makes it possible to raise by a hand-operated traveling crane the entire apparatus to the operating floor for removal if need be, or merely the cooling coils or windings should some defect develop.

Each transformer requires 9 gal. of water per minute. To fulfill this demand and that of the turbine oil coolers, an independent cooling line drawing from the condenser intake has been provided. A 3-in. motor-driven centrifugal pump circulates the water. As the basement is below the river, an open discharge would entail repumping the cooling water to the sewer. For this reason a closed discharge was employed and all the pumping is done in one operation. A sight-flow indicator visible from the operating floor shows to the attendant the quantity of water passing through the transformer. A thermometer on the case also gives the oil temperature and by means of electrical contacts sounds a bell alarm when the temperature reaches a predetermined point.

For the generators and rotary converters an air-cooling system has been provided. The air is taken from the outside, washed and distributed to the machines. Provision is made for recirculation in cold weather. The intake, 7 ft. above the ground, is a walled-in compartment with steel sash windows in both the outer or building wall, and in the inner wall, the former being provided with screens to keep out rubbish.

In summer the air comes in through the outer wall, and in the colder weather it is drawn from within. In either case the air is pulled down into the basement through a duct leading to the suction chamber of the cleaning apparatus, passing through a water spray to a motor-driven fan having a capacity of 60,000 cu.ft. per min. The cooling water is circulated by a 4-in. motor-driven centrifugal pump, drawing from the suction chamber at the bottom of the air washer. The water is forced through the nozzles and drops back into the suction chamber. As soon as it becomes dirty it is replaced with clean water. After being washed and cooled the air is distributed to the machines. That passing through the generators is discharged to the suction of the forced-draft fans in the boiler room. The delivery to each generator is 15,000 cu.ft. per min., and to the rotary-converter room 30,000 cu.ft. of air per minute passes through four openings. These openings are immediately below each rotary, so that the air passes through the machines and into the room, keeping the latter at a pressure slightly above atmospheric.

Less Coal Used When Engine Is On

In some buildings in which an engine in the basement supplies light and power for the machinery on the various floors during the day, it is found that at night and on holidays when the plant is shut down and steam for heating is taken through a reducing valve, more coal is used per hour than when the plant is in operation, exterior weather conditions remaining about the same. It is true, of course, that the engine adds no heat to the steam, but on the contrary takes some heat away—only a small percentage of the total heat in the steam, to be sure, but where is the joker?

One of the points often overlooked in such cases is the fact that nearly all the energy of the engine may be given up to the air throughout the building, in the form of heat. Each electric light, motor and bearing gives off heat in its operation, so that most of the heat energy taken from the steam at the engine is given up again in heat, delivered, through the medium of the wires, lineshaft or belts.

The action of the belts or machinery in motion has another important influence; namely, the distribution and equalization of the heat. This is of greater importance than may at first appear, for buildings having badly distributed radiation may be reasonably well heated by vigorous air currents while machinery is in motion, but may be greatly overheated near the radiators—probably located near windows—when the machinery is idle. The radiators to the windward side of the building are on full, trying to temper the air inleakage, while those on the opposite side are overheating locally so that all the outgoing air is at a very much higher temperature than the average in the room. This condition may prevail even with a first-class automatic temperature-control system, but to a much greater extent with a manual control, which usually means no control at all.

Overheating, either local or general, is a condition that is likely to exist during a shutdown period. This is sufficient in most cases to easily account for all the excess fuel used. The heat loss from a building is considered to be directly proportional to the difference in temperature between the inside and outside air, although it is probably proportionately and progressively greater as these temperatures differ, especially as the indoor temperature increases. In other words, it is likely that considerably more heat will be required to maintain a building at 80 deg. when it is 30 above zero outdoors than to keep 70 deg. inside when it is 20 above zero outside. At any rate, with a temperature difference of 40 deg., then 4 deg. increase would mean 10 per cent. or 10 deg. would mean 25 per cent. more heat lost. This is more heat than the engine takes out of the steam. That more coal is used on Sundays, nights and holidays, therefore, does not seem at all unlikely.

New West Penn Power Plant

Government officials have made arrangements with the West Penn Power Co. for the erection of a large electric power generating plant in the Allegheny Valley to cost approximately $5,000,000 and designed to help relieve the serious situation caused by insufficient power to meet the demands of the numerous war industries in and about Pittsburgh. The plant will be located near the coal mine of the company, and it is understood contracts have already been made for two turbo-generators of 20,000 kw. each. The plan also provides for the erection of the necessary transmission lines throughout the Connellsville coke region.

Graphic Method of Determining Size of Safety Valve

By H. F. GAUSS

Reasons for increasing maximum allowable lifts above those permitted in the A.S.M.E. Code. Napier's formula for flow of steam through an orifice used as a basis for constructing capacity curves. General solution by means of logarithmic charts.

THE following simple method of determining the proper size of safety valve for a steam boiler is based on the rules and data set forth in the A.S.M.E. Boiler Code. A modification, however, has been made in the maximum allowable lifts. These have been increased 25 per cent. above those given in the Code, for

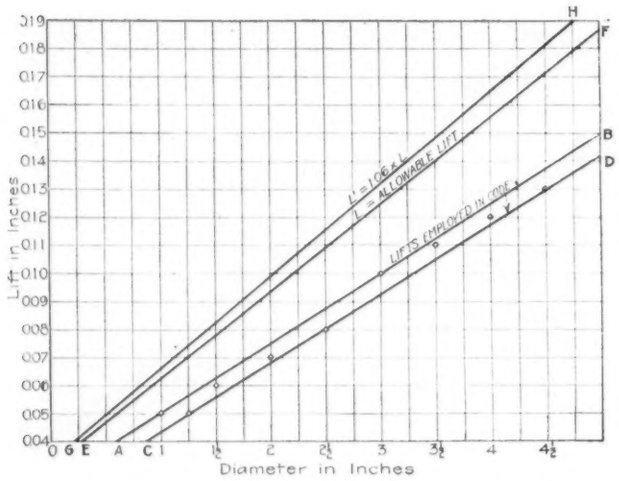


FIG. 1. RELATION OF LIFT OF VALVE TO DIAMETER

the following reasons: First, it is possible to manufacture successfully safety-valve springs capable of these higher lifts; second, by using the lifts recommended in the Code, the number and size of valves required are much greater than the results of safe practice show to be necessary; third, the safety valve in any event can only take care of a gradually increasing pressure and is no protection against a sudden increase, due to a ruptured plate, and so the large margin of safety secured by restricting the maximum lifts to extremely low values is not warranted. The discharge capacity of a safety valve increases rapidly with an increase of pressure, and this feature in itself affords a measure of protection. For example, the capacity of a 3-in. safety valve on a boiler carrying 100 lb. pressure increases 32.2 per cent. for an increase in pressure of 25 pounds.

In Fig. 1 the lines *AB* and *CD* indicate the limits of the maximum lifts employed in constructing the safety-valve tables in the A.S.M.E. Boiler Code. It will be noticed that a constant lift is employed for each size of valve regardless of the pressure. This is reasonable when it is considered that the diameter of the spring is controlled by the size of the valve and a spring with a small diameter is necessarily stiff. Assuming that lifts 25 per cent. greater than the maximum of the range indicated in Fig. 1 are possible, it is easy to determine a new line *EF* indicating the maximum possible lifts for valves of various diameters.

Napier's law for the flow of steam through an orifice when the pressure on the discharge side is less than 58 per cent. of the pressure in the boiler is

$$W = \frac{AP}{70}$$

in which

W = Pounds of steam discharged per second;
A = Area of orifice in square inches;
P = Absolute pressure in pounds per square inch.

Ordinarily a constant of discharge for a particular orifice should be used when applying this formula in determining the discharge of a safety valve. For the present purpose, however, it will be assumed that this constant is included in the lift allowed.

To use Napier's formula in designing safety valves, it is desirable to make some modification in the terms. The area through which the steam must flow is the

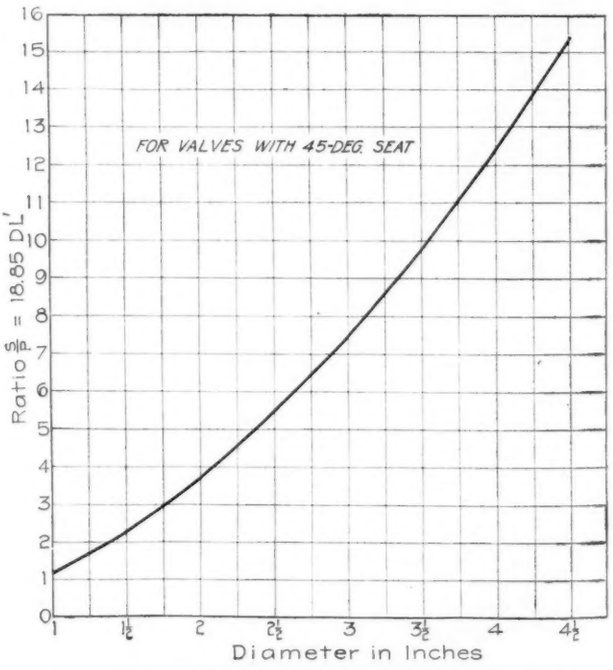


FIG. 2. CURVE FOR FINDING SIZE OF SAFETY VALVE WITH 45-DEGREE SEAT

product of the circumference of the throat and the lift normal to the seat of the valve. For 45-deg. seats,

$$A = 3.1416\,D \times 0.7\,L$$

and for flat seats,

$$A = 3.1416\,D \times L$$

in which

A = Area through which steam flows;
D = Circumference of valve throat;
L = Vertical rise of valve.

The A.S.M.E. Boiler Code states that the minimum capacity of a safety valve or valves to be placed on a boiler shall be determined on the basis of 6 lb. of steam per hour per square foot of boiler-heating surface for

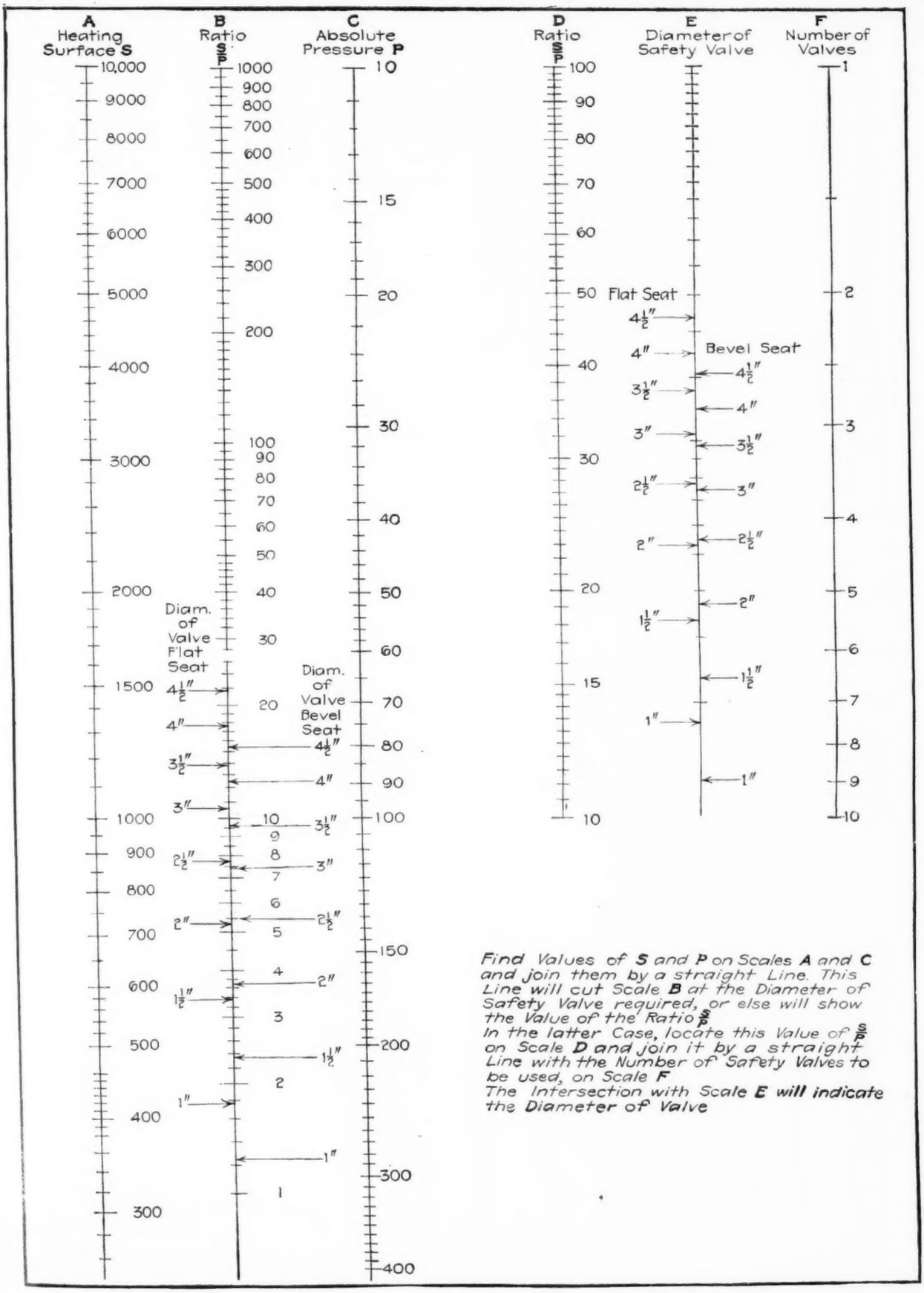


FIG. 3. ALIGNMENT CHART FOR FINDING THE SIZE OF SAFETY VALVE

water-tube boilers and 5 lb. for all other boilers, etc. On a basis of 10 sq.ft. of heating surface per horsepower for water-tube boilers, an evaporation of 6 lb. of water per square foot of heating surface amounts to 60 lb. per rated horsepower, which is equivalent to approximately 200 per cent. of normal rating. On a basis of 12 sq.ft. of heating surface per boiler horsepower for shell boilers, an evaporation of 5 lb. per sq.ft. per hour also amounts to 200 per cent. of normal rating.

It has become customary with many manufacturers to rate all their boilers at 10 sq.ft. per boiler horsepower, and in the present discussion no difference will be made in the evaporative power of the heating surface of any of the various types of boilers, and all

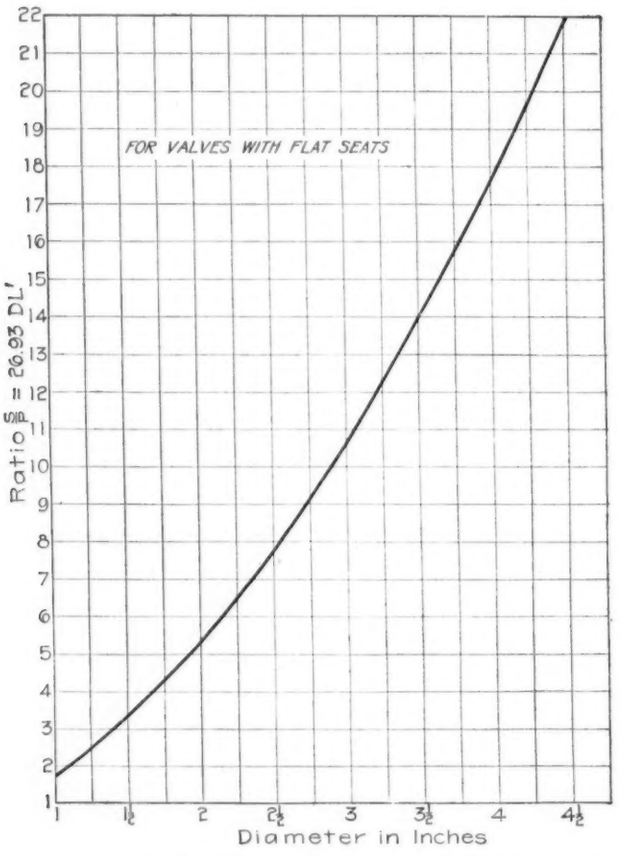


FIG. 4. CURVE FOR FINDING SIZE OF SAFETY VALVE WITH FLAT SEAT

will be assumed to be capable of evaporating 6 lb. per sq.ft. per hour. Then, if S = total heating surface, the evaporation per hour becomes $6 \times S$, and the evaporation per second is

$$W = \frac{6 \times S}{3600}$$

Substituting in Napier's formula the value for A of $3.1416\,D \times 0.7\,L$ and for W of $\frac{6 \times S}{3600}$, there results

$$\frac{6 \times S}{3600} = \frac{3.1416D \times 0.7L \times P}{70}$$

The Code limits the pressure rise to 6 per cent.; that is, the capacity of a safety valve must be sufficient to discharge all the steam the boiler can generate without permitting a rise in absolute pressure of more than 6 per cent. of that at which the valve is set to pop. Introducing this 6 per cent. factor in the preceding equation,

$$\frac{6 \times S}{3600} = \frac{3.1416D \times 0.7L \times 1.06P}{70}, \text{ or } \frac{S}{P} = 18.85D \times 1.06L$$

If L' is written for $1.06\,L$, $\frac{S}{P} = 18.85\,DL'$

The line GH, Fig. 1, gives the values of L' corresponding to various values of D and the curve in Fig. 2 represents values of $\frac{S}{P}$ for corresponding values of D and L'. From the latter curve it is possible to determine directly the size of the valve required when the heating surface and the absolute working pressure are known and the ratio $\frac{S}{P}$ lies within the range of the curve. Since the capacity of a valve varies with the circumference and not the area, it is directly proportional to the throat diameter; that is, for a fixed lift, a 4-in. valve has twice the capacity of a 2-in. valve and a 6-in. valve twice that of a 3-in. valve. Hence, if the ratio $\frac{S}{P}$ is beyond the range of the curve in Fig. 2, it must be divided by a number sufficiently large to make the quotient so obtained come within the range of the curve. The divisor thus found is the number of valves required, and the size is determined by the quotient. No safety valves larger than 4½ in. are permitted.

As an example, let it be required to find the number and size of safety valves for a 350-hp. water-tube boiler carrying a gage pressure of 185 lb. The absolute pressure is $185 + 15 = 200$ lb. and the heating surface is $10 \times 350 = 3500$ sq.ft.; hence, $\frac{S}{P} = \frac{3500}{200} = 17.5$. This value is beyond the range of the curve in Fig. 2, so assume two valves. Dividing 17.5 by 2, the quotient is 8.75, which, in Fig. 2, corresponds to a valve about 3¼ in. in diameter. The nearest commercial size is 3½ in., and so two 3½-in. valves will be required.

To facilitate the operations outlined, the chart in Fig. 3 has been prepared. The manner of using the chart is evident and the construction involves only the simple use of logarithmic scales for division. Scale A represents graphically the logarithms of the dividend S. Scale C represents the logarithms of the divisor P, and scale B represents the logarithms of the quotient $\frac{S}{P}$. When the ratio $\frac{S}{P}$ falls within the range of the curve in Fig. 2, the size of valve required can be read direct from scale B. When the ratio $\frac{S}{P}$ is beyond the range of the curve, it must be divided by a number sufficiently large to bring it within the range. This is accomplished graphically in Fig. 3 by means of scales D, E and F. Scale D represents logarithms of the ratio $\frac{S}{P}$, scale F represents logarithms of the divisor (the number of valves required), and scale E represents logarithms of the quotient, with the corresponding size of valve necessary indicated.

To illustrate, suppose the number and size of valves for a 400-hp. boiler operating at 135 lb. gage are to be found. The heating surface is $S = 400 \times 10 = 4000$ sq.ft. and the pressure is $P = 135 + 15 = 150$ lb. On Fig. 3, connect 4000 on the A scale with 150 on the C

scale, using a straight-edge, and the line will cut the B scale at 26. As 26 is beyond the range of the curve in Fig. 2, assume that two safety valves are used. Then connect 26 on the D scale with 2 on the F scale, Fig. 3, and the line will cut the E scale very close to 4 on the right-hand side of the scale. Hence, two 4-in. bevel-seat valves will be required.

In case valves with flat seats are used, the lift is equal to the vertical rise of the valve and is L instead of $0.7L$, so that the general equation becomes

$$\frac{6 \times S}{3600} = \frac{3.1416D \times L \times 1.06P}{70}$$

from which

$$\frac{S}{P} = 26.93DL'$$

Fig. 4 is a curve by which the size of flat-seat valve can be found direct, so long as the ratio $\frac{S}{P}$ is within the range of the curve. For values of $\frac{S}{P}$ greater than 21.92, the chart in Fig. 3 may be used. The diameter of flat-seat valve must be read from the left-hand side of scale B or scale E, however. The method of using the chart for finding the number and size of flat-seat valves does not differ in principle from that already explained in connection with bevel-seat valves.

Some of the Bits Your Liberty Bond Will Do

If you buy a $100 bond of the Fourth Liberty Loan you are lending the United States Government enough money to feed a soldier in France a little more than seven months. Or you have furnished enough money to give him a complete outfit of winter and summer clothing, including shoes and stockings, and slicker and overcoat and blankets, with enough left over to arm him with a good revolver. You have done that much to beat back the Hun.

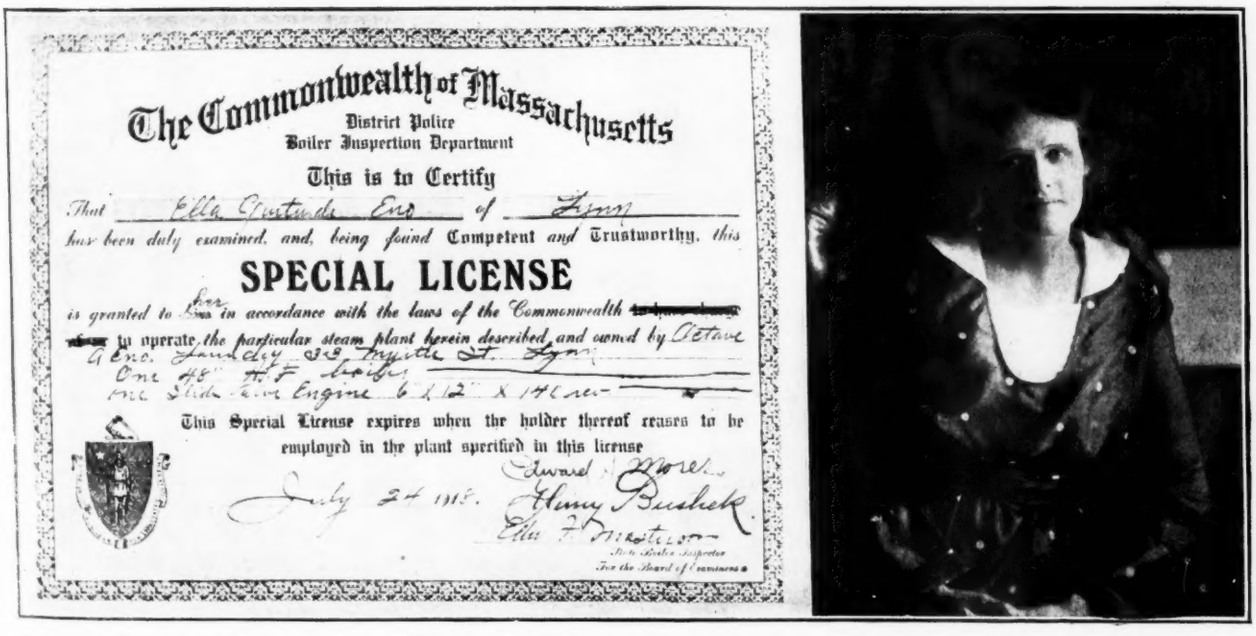
It takes $35 more to arm him with a rifle with a bayonet on it, and if you buy a second $100 bond you furnish him this rifle and 1000 cartridges for it; and there will still be enough of your money left to purchase a good-sized bomb to throw in a dugout, or demolish a machine gun together with the Huns operating it.

Massachusetts' Only Licensed Female Engineer

Mrs. Ella Gertrude Eno, the only licensed female engineer in Massachusetts, was born at North Lawrence, N. Y., and now resides in Lynn, Mass., where she and her husband conduct the Star Wet Wash Laundry. Mr. Eno is a licensed engineer and it was under his tutelage that Mrs. Eno acquired the knowledge and experience which enabled her to pass the necessary examination and secure an engineer's license.

The plant consists of a horizontal return-tubular boiler 48 in. by 16 ft., carrying a working pressure of 50 lb.; a 6 x 12-in. horizontal, slide-valve engine running at 140 r.p.m., and the steam pumps, receivers, traps, etc., usually found in a laundry plant. Mrs. Eno actually operates the plant, doing the firing and caring for the engine and appliances, and incidentally the coal consumed has decreased nearly 50 per cent. since she took charge. The following is quoted from a local daily:

> Refuting the argument that laborious work hardens a person, right here in Lynn is a dainty, entirely feminine little woman, who holds the distinction of being the only licensed woman engineer in Massachusetts.
>
> "It is nothing at all," said Mrs. Eno, when she was called away from her work down at the far end of the laundry. "For four weeks we advertised and tried in every way to get an engineer, because it was necessary for my husband to go out on the wagons. But labor is indeed hard to get these days, and it looked as though we would be left without an engineer. I was familiar with the work and decided it was up to me, and so I began in earnest to learn just what must be done to keep the power up and the hundred and one things that go to make up an engineer's education. A little more than two months ago I passed the examination, and now have my license. While I would not seek work of just this kind, still, women must be glad to fill the places made vacant by the boys in war service."


The Commonwealth of Massachusetts
District Police
Boiler Inspection Department
This is to Certify
That Ella Gertrude Eno of Lynn
has been duly examined, and, being found Competent and Trustworthy, this
SPECIAL LICENSE
is granted to her in accordance with the laws of the Commonwealth to operate the particular steam plant herein described and owned by herself
E. Eno Laundry 39 Myrtle St. Lynn
One 48" H.R.T. boiler
One Slide Valve Engine 6 x 12" x 140 r.p.m.
This Special License expires when the holder thereof ceases to be employed in the plant specified in this license
July 2nd 1918.
Edward L. Morse
Henry Bushek
Ella F. Nickerson
State Boiler Inspector
For the Board of Examiners

THE ONLY ENGINEER'S LICENSE HELD BY A WOMAN IN THE STATE OF MASSACHUSETTS AND THE WOMAN

The Electrical Study Course—Motor-Speed Control

Treats of the various means used to regulate the speed of the three usual types of motors and points out the limitations of the different methods.

HAVING considered the problems incident to starting motors and what their solutions are, in the previous lesson, we will now proceed to take up another problem in connection with their operation; namely, speed control. It is true that for many classes of service only one speed is required and in such no speed control need be provided, but there are many others which do require adjustable speed in operation.

As heretofore, the shunt motor will be the one first selected for discussion. The most valuable characteristic of this type is the fact that it maintains a practically uniform speed for any load within its capacity. It has already been found that one method of changing the speed is to change the field current, thus changing the amount of magnetic flux, and that the speed once

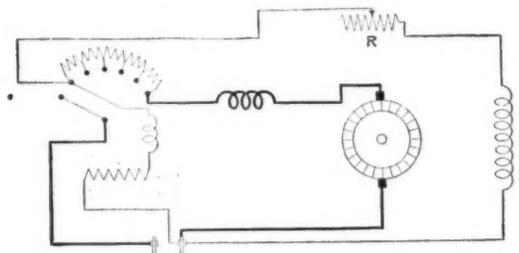


FIG. 1. CONNECTION DIAGRAM OF SHUNT MOTOR WITH RHEOSTAT FOR REGULATING FIELD CURRENT

so changed will again remain constant at the new value until such time as some other adjustment of field current is made. The field current may be varied by means of a field rheostat placed in series with the field winding as indicated by *R* in Fig. 1, which also shows the starting box connected into the motor circuit. One of the standard types of such field rheostats is illustrated in Fig. 2. The change of speed that can be obtained in an ordinary shunt motor by means of field-current control is rather limited. The lowest speed obtainable is that which the motor has when all the resistance in rheostat *R* is cut out, since the maximum field current then flows, and, as we already know, the speed of a shunt motor varies inversely as the field current. The limit to which the speed may be increased by decreasing the field current is determined by the sparking at the brushes which results from the operation of the armature in a weakened magnetic field. Ordinarily, an increase of about 25 per cent. above the speed obtained with maximum field current is considered to be allowable. Speed regulation by means of field-current control is much more satisfactory when used in connection with interpole motors. The field condition required for proper commutation is then always maintained and sparking at the brushes is practically eliminated even when great changes in field strength are made. For adjustable speed operation such motors are designed to run very slowly when the field coils are taking their maximum current; that is, when the field windings are connected directly to the mains. A field rheostat of high resistance is then used to reduce the field current in steps

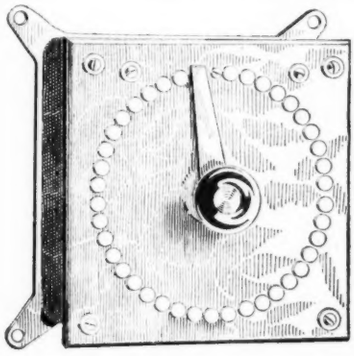


FIG. 2. RHEOSTAT USED FOR REGULATING THE SHUNT-FIELD CURRENT OF MOTORS OR GENERATORS

from its maximum value to such a value as will give the greatest speed at which it is safe to operate the motor. The range in speed obtainable is many times that possible for a shunt motor without interpoles. Often the field resistance is incorporated in the starting box so that only one piece of apparatus is necessary for the complete control of the motor. Such a combined motor-starting and speed-control rheostat is illustrated in Fig. 3, the diagram of connections being given in Fig. 4. There are two arms *a* and *b*, one making contact with buttons *e* and the other with buttons *f*, and both pivoted at *c*. The former is for starting the motor and the latter for regulating its field current. There is only one handle, however, and that is fastened to lever *b*. In this way arm *a* can be moved only together with arm *b*, or, more correctly speaking, arm *b* must be moved in order to move arm *a*. When

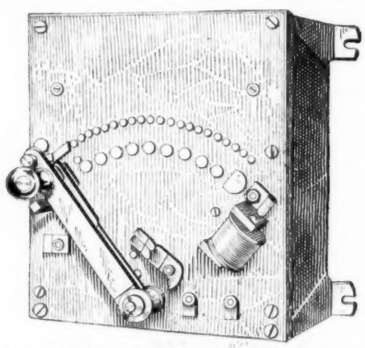


FIG. 3. MOTOR-STARTING RHEOSTAT WITH FIELD RESISTANCE FOR ADJUSTING SPEED OF SHUNT MOTORS

arm *a* is brought as far to the right side as it will go, it is held in position by the no-voltage release magnet *d* in exactly the same way as the arm of an ordinary starting box, and when it is brought to this position the contact *g* is opened. Only arm *a* is actuated by a spring to force it to return to the "off" position when the magnet *d* releases it. The arm *b* will remain on whatever contact it is placed when it is no longer im-

pelled by arm *a* to return to the "off" position with it. This is the case when arm *a* is held by the magnet *d* and then the arm *b* is free to be moved backward over the contacts *f*, thereby inserting resistance into the field winding circuit and causing the motor to run at a greater speed by decreasing its field current. When the arm *a* is released from the magnet *d*, its spring causes it to snap back to the "off" position, and in doing

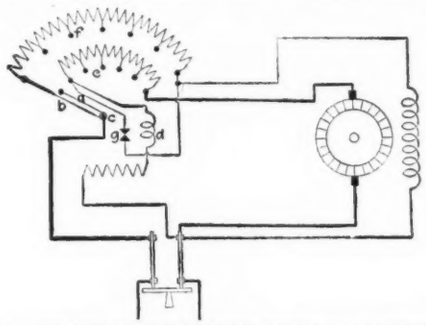
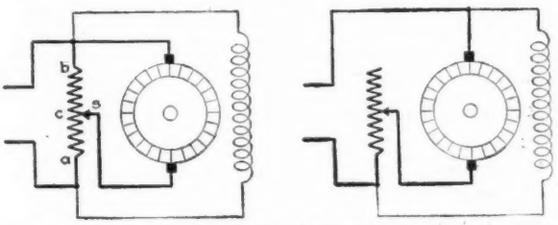


FIG. 4. DIAGRAM OF SHUNT MOTOR CONNECTED TO AN ADJUSTABLE-SPEED MOTOR-STARTING RHEOSTAT

so it carries back the arm *b* with it and prepares the box for starting duty again. Shunt motors should in all cases be started only when there is no resistance in the field circuit; that is, when the field current is a maximum.

When the speed of a shunt motor is to be varied between wider limits than can be obtained by field current control it becomes necessary to provide means for adjusting the voltage across the armature. The speed of a shunt motor is practically proportional to the voltage across its armature, provided the field current remains constant. This follows from the fact that the armature revolves at whatever speed is required to generate the proper value of counter-em.f. If the impressed voltage is reduced by one-half, for example, the



FIGS. 5 AND 6. CONNECTION DIAGRAMS FOR ADJUSTABLE-SPEED OPERATION OF SHUNT MOTORS BY MEANS OF RESISTANCE IN ARMATURE CIRCUIT

counter-em.f. will need to be only about one-half of its former value, and since the field strength is not changed the speed need be only one-half of what it was before to generate half the original counter-em.f.

One method of adjusting the voltage across the armature is to place resistance in series with it. If the resistance be arranged as in Fig. 5 any voltage desired, from zero to the full line voltage, may be impressed upon the armature. When the moving contact of the rheostat is in the position *a*, it will be seen that the armature is connected directly to the line. When in position *b* both terminals of the armature are connected to one side of the line and hence there is no voltage across them. For intermediate positions of the contact, such as *c*, the voltage across the armature terminals will lie in between these values; it will be the line voltage minus the drop in voltage across the part *ac* of the rheostat. This method does not give very satisfactory speed control except when the load on the motor is constant, for the following reason: Suppose that while the contact is at *c* the load on the motor increases. There will be a corresponding increase in the armature current and consequently a greater drop in voltage across the resistance *ac*, thereby reducing the voltage across the armature and reducing its speed. The method is, moreover, wasteful since current flows through the rheostat even when the contact *s* is at *a*. This constant source of loss could be overcome by connecting the rheostat as shown in Fig. 6, in which case

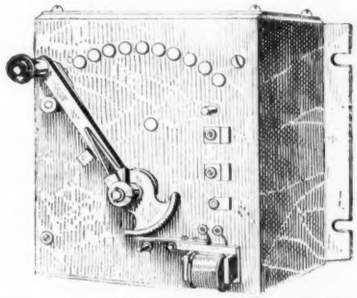


FIG. 7. MOTOR-STARTING RHEOSTAT INTENDED FOR ADJUSTABLE-SPEED OPERATION BY ARMATURE-RESISTANCE CONTROL

there would be a loss only when the resistance was in use, but it would be impossible to get any very low speeds unless the resistance of the rheostat were made quite high. With either connection it would not be obligatory to use a starting box unless it was considered necessary to provide the protection given by the no-voltage release mechanism. Starting boxes containing resistances especially designed to carry current continuously are often used for the purpose, and others are made to incorporate both the field-control and arma-

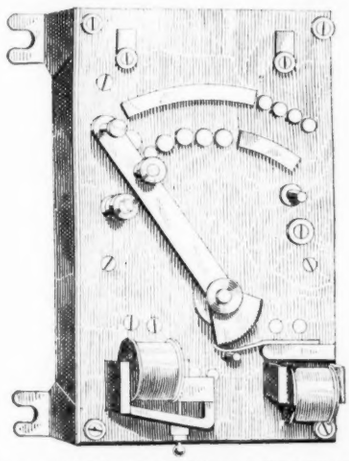


FIG. 8. MOTOR-STARTING RHEOSTAT FOR ADJUSTABLE-SPEED OPERATION BY MEANS OF BOTH ARMATURE AND FIELD CONTROL

ture-control features. Such starting rheostats are shown in Figs. 7 and 8.

There is a much more satisfactory method of obtaining an adjustable voltage, but it entails the use of a considerable amount of additional apparatus. It is, however, used where absolute control from zero to full speed is indispensable. In that case a motor-generator

set is provided in place of the rheostat and the connections are made as shown in Fig. 9, in which *M* is the motor whose speed is to be adjusted, *G* is a generator which is driven by another motor *X* connected to the line through a starting box *g* in the usual manner. The field winding of motor *M*, shown at *a*, is connected directly to the mains, but its armature is con-

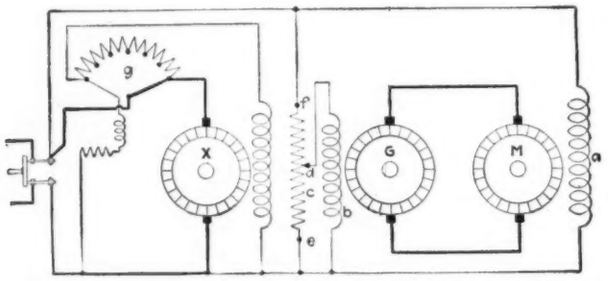


FIG. 9. CONNECTION DIAGRAM FOR SHUNT MOTOR-SPEED CONTROL BY MEANS OF ADJUSTABLE VOLTAGE ACROSS ARMATURE FURNISHED BY SPECIAL MOTOR-GENERATOR SET

nected to the armature of *G*, which is operated as a separately excited generator. By means of the field rheostat *c* the current through the generator field *b* can be regulated to have any value from zero to the maximum by sliding the contact *d* from *e* to *f*. The voltage of the generator is correspondingly adjustable through a range of zero to maximum volts, and consequently that of the armature of motor *M* likewise. The speed of the motor can therefore be adjusted to any value desired between standstill and that which it develops when connected to normal voltage. By placing a reversing switch in the generator field circuit, the current through its field can be reversed. This would reverse the polarity of the generator, thus reversing the direction of the current through the motor armature and causing it to revolve in the opposite direction to that in which it ran before. We thus have a system in which the speed can be adjusted in very small and uniform steps from zero to full speed in either forward or reverse direction.

We now come to a consideration of series motors. Since the field winding of this type of machine is in

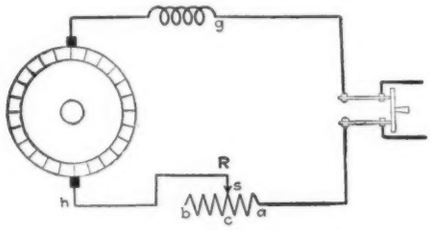


FIG. 10. CONNECTION DIAGRAM FOR SERIES MOTOR SHOWING SPEED-REGULATING RESISTANCE

series with the armature, any control which affects the field current must affect the armature current at the same time. It must also be remembered that the machine is inherently a variable-speed one and that it suffers a change in speed for every change in load. The speed remains constant, however, if the load and the impressed voltage are constant. If it is desired to change the speed when the load is constant, the impressed voltage must be changed, and this is accomplished by placing resistance in series with the machine, as illustrated at *R* in Fig. 10. The voltage across *gh* will be the line voltage minus the voltage drop across *ac*, which remains constant so long as the current remains so. When the load changes, the current will change and consequently the voltage across *ac* will change. Assume, for example, that the resistance

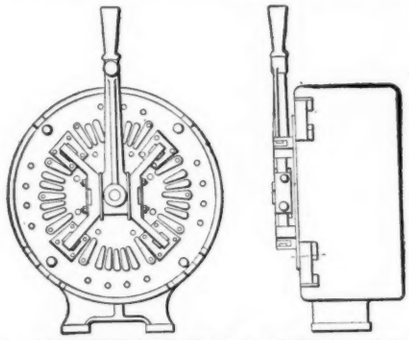


FIG. 11. CONTROLLER FOR STARTING AND REGULATING SPEED OF SERIES MOTORS

ac is 0.1 ohm and that the motor is taking 20 amperes at a line voltage of 110 volts. The voltage drop across *ac* will be its resistance 0.1, multiplied by the current through it, 20 amperes, or $0.1 \times 20 = 2$ volts, and the drop across *gh* will be the line voltage, 110 volts, minus the drop across *ac*, or $110 - 2 = 108$ volts. Suppose, now, that the load is increased so that the motor takes 80 amperes. The drop across the resistance *ac* will then be 0.1 ohm $\times$ 80 amperes $=$ 8 volts, and the voltage across *gh* will be $110 - 8 = 102$ volts. The speed of the motor would consequently be lowered as in the case of the shunt motor, but in the series machine we have the further effect of the increase in field current which of itself would cause a considerable decrease in speed. The combined effect is to cause a greater decrease in speed than that due to either cause alone. The lowest speed would be obtained with contact *s* at *b* and the highest with it at *a*. The change in speed due to the change in voltage drop across the resistance when the load varies is not objectionable in the case of a series motor since the speed would change anyhow, and therefore control of speed in this class of machines is ac-

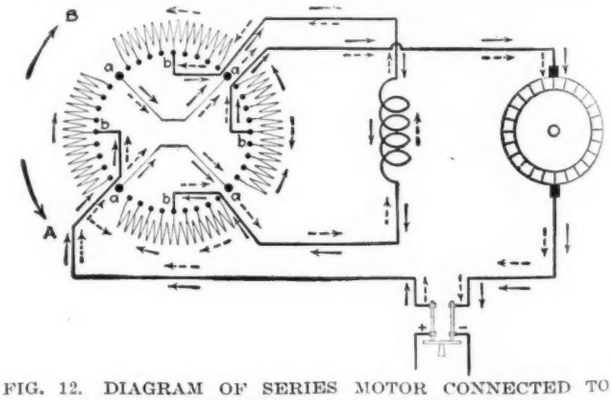


FIG. 12. DIAGRAM OF SERIES MOTOR CONNECTED TO CONTROLLER INTENDED FOR STARTING DUTY AND VARIABLE-SPEED CONTROL

complished by means of resistance placed in series with them. Since a heavy-duty starter must be provided with a series motor, this same device is used as a speed controller. Fig. 11 is an illustration of a type that is used extensively for crane control and similar applications. Since it is necessary in such service that the

motor run in either forward or reverse direction at will, provision for such control must be made. We know that in order to reverse the direction of rotation of a motor the direction of the current in either the armature or field coils must be reversed. If we were to reverse it in both, the direction of rotation would remain the same as it was. It will therefore not do to reverse the connections of the entire motor, but only those of the field or of the armature. Fig. 12 will make it clear how this is accomplished.

When the contact arm is moved in the direction *A*, the path of the current will be as indicated by the solid

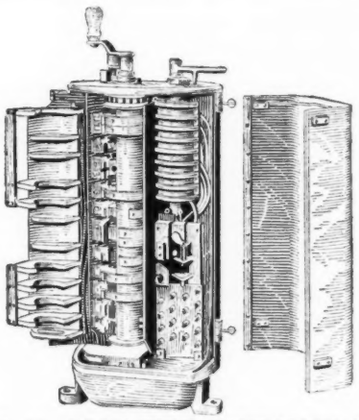


FIG. 13. DRUM-TYPE CONTROLLER FOR SERIES-MULTIPLE CONTROL OF SERIES MOTORS

arrows. When it is moved in the direction *B*, the current will follow the path of the dotted arrows. The direction of the current through the armature will be seen to be the same in either case, but that through the series field is shown to be reversed. When the contact arm is in position *a*, no current flows; as it is moved in either direction the current increases until it reaches position *b*, at which point all the resistance has been cut out. Moving it in either direction from this contact again inserts resistance into the circuit, thus cutting down the motor speed.

Another type of controller used in connection with series motors, known as the "drum" type, is shown in Fig. 13. Only the contacts are contained in the controller itself, the resistances being placed in any convenient location. This is the type commonly used for street-car operation, and it is adapted for "series-multiple" control. This is a type of control used when two series motors (or some multiple of two) are arranged to drive a certain load between them. The connections are so arranged that upon starting the machines are connected in series. The voltage across each is then one-half the total, and consequently, when all the starting resistance is cut out, they operate as if each were connected to a source of voltage equal to one-half the normal and therefore they run at a reduced speed. When it is desired to run faster, the connections are quickly broken and remade with the motors in multiple but each connected in series with its starting resistance, which is then cut out again until the motors are connected directly across the full voltage. Such controllers are fitted with an extra set of contacts operated by a separate handle, for reversing the direction of rotation of the motors by reversing the field or armature terminal connections.

In multiple unit systems, which are the ones used when a train of cars is to be operated from a single point on the train, such as the front platform of the first car, a "master controller" is provided which regulates the functioning of the controller itself, causing it to cut in or cut out resistance according to the movement of the master controller. All the master controllers on the train are connected in multiple by means of connectors between the cars, and the movement of any one of them will cause the main controllers on all the cars to operate in unison. The operation of the main controllers is regulated by means of the motor currents in such a manner that they cannot cut out their starting resistances too quickly, and there are other safeguards which prevent the motors from being subject to overload. The connections for such systems are quite complicated and require some patience to trace out, but as in all automatic control the complications are merely due to the auxiliary apparatus used. The principle of starting, stopping and speed control is precisely the same as that employed in hand-operated controllers.

Only the compound motor remains for discussion, and its speed regulation presents no problems that have not already been encountered. In fact it resembles a shunt motor very much more closely than a series and from the standpoint of speed control may be treated in the same manner as the shunt type.

There were two problems presented for solution in the previous lesson. The first was to find the starting-box resistance required to limit the starting current of a 50-hp. 240-volt motor to approximately $1\frac{1}{2}$ times the full-load current, the resistance of the armature being given as 0.07 ohm. The full load output will be the horsepower capacity of the machine times 746, or $50 \times 746 = 37{,}300$ watts. Neglecting the losses in the machine, the current taken by it will be the watts output divided by the voltage; that is, $\frac{37{,}300}{240} = 155$ amperes. Since the load current is to be $1\frac{1}{2}$ times this value, it will be $\frac{3}{2} \times 155 = 233$ amperes. The total resistance in the circuit would have to be the voltage divided by this current, or $\frac{240}{233} = 1.03$ ohms. The armature itself has a resistance of 0.07 ohm, consequently the resistance it would be necessary to place in series with it would be $1.03 - 0.07 = 0.96$ ohm.

The second problem is to find the current required at 110 volts to heat a room 15 ft. long by 10 ft. wide by 9 ft. high if it is necessary to supply 2 watts per cubic foot to keep the room at the desired temperature. The total energy required to heat the room would be its capacity in cubic feet times 2 watts for each one. Its capacity is $15 \times 10 \times 9 = 1350$ cu.ft., and $1350 \times 2 = 2700$ watts. Dividing the number of watts required by the voltage gives the current input, or $\frac{2700}{110} = 24.5$ amperes.

It is required to heat 50 gal. of water from 50 deg. F. to 170 deg. F. in 6 hours. Assuming that there is no loss of heat during that time, how many amperes would be required at 230 volts? What would be the resistance of the heater? If the heater consisted of four sections in multiple, what would be the resistance of each section?

The Chicago Situation Explained

IN SPREADING information on mechanical matters the daily press has an unfortunate reputation for inaccuracy. Among engineers this is commonly known, but when individual interests are affected the reader is inclined to swallow bait, hook and sinker and in addition allow his imagination full sway before attempting to check the details or prove the veracity of the story. Something on this order recently happened in Chicago. The daily papers came out with announcements to the effect that it was the intention of the Fuel Administration to transfer the services of power plants within the loop to the Commonwealth Edison Co. for the duration of the war, thereby saving immense quantities of coal expressed by the difference between 2 lb. and 8 or 10 lb. per kw.-hr. Mention was also made of the transfer of energy now taking place between the Sanitary District and the Edison company. Such unqualified statements caused considerable commotion, and rumors soon became current that the Fuel Administration was packed with central-station men playing into the hands of the home company and that the latter was benefiting to an unwarranted extent from the electrical energy obtained at a very low price from the Sanitary District.

Injustice to Illinois Fuel Administration

That these reports and the rumors following in their wake are incorrect is putting the case mildly. They are altogether misleading and do rank injustice to the representatives of the Fuel Administration serving the State of Illinois. Careful scrutiny of the work so far done or in contemplation shows unbiased action and that the leaning, if anything, is away from the central station, to forestall any such criticism as previously cited. The primary object is to conserve coal, and they are doing this to the best of their ability. No favoritism is being shown, and each case is being settled on its merits. Adjacent plants are being called upon to combine their services where it will result in a saving in coal, the better plant supplying its less efficient neighbor. The purchase of summer current in noncondensing plants where there is little use for exhaust steam is another recommendation offered. It was the latter that caused the commotion in Chicago.

With coal costing between $5 and $6 per ton, good firemen scarce, and with little use for exhaust steam outside of heating service water, there are a number of buildings within the loop, especially those equipped with electric elevators, that at the central-station rates now existing might profitably buy current during the nonheating season. At least, a saving in coal might be made, and this is what interests the Fuel Administration. This was the suggestion offered by the administrative engineer, and it is to be noticed that it was only a suggestion. Action on the part of the plant owner was to be voluntary as it was considered that the situation, for the present at least, did not warrant compulsion.

Owing to delay in appointing an administrator the summer was half gone before the work could be organized. As it turned out, only one plant took advantage of the situation, and even here negotiations were instigated by the chief engineer himself. The plant is located in the Lumber Exchange Building, of which mention was made in the Aug. 13 issue of *Power*. At the beginning of the heating season, Oct. 1, the plant will be put back into service. As the summer is practically over, it is not likely that any other building will make a similar change, although preparation for a change of service next summer may be in order.

Edison Company Obtains No Special Advantages

The arrangements between the Sanitary District and the Commonwealth Edison Co. are perfectly legitimate. At least there is no advantage accruing to the latter as they are buying surplus current from the Sanitary District at their coal cost for generating the same amount of energy. Some 4000 kw. will be available during the day for the spring, summer and fall, and when the lake level is high, as it is this year, the surplus will be a little greater. The amount purchased is a mere drop in the bucket when compared to the total load. It does not permit shutting down any of the large units employed, nor can a part of the operating force be eliminated. The coal cost then is all that is saved, and this is turned over to the Sanitary District, giving to the taxpayer a neat sum at the end of the year that could not be obtained otherwise. It is merely one of the numerous plans to save coal, and on the part of the Edison company one of the many patriotic duties it has been performing to help win the war.

The question naturally arises, why the Sanitary District does not increase its commercial day load and obtain more money for its surplus product. The fact is that it is already carrying about all the load that can be served the year around. Off-peak customers for six months in the year are hard to get, and it would be difficult to estimate beforehand the exact amount of power that would be available, as this depends on the lake level. For a number of years it has averaged about one-half foot above datum during the summer and about one-half foot below datum during the winter. This summer the level has reached two feet above datum, and a year from date it might not rise above datum. The power possibilities then are uncertain, so that it is rather convenient to dispose of all surplus at a fair figure. For Sundays and holidays, when the Edison load may be supplied by the most efficient units, the present rate may be computed by multiplying the cost of coal per ton to the central station by 0.0009, and for week days, when part of the load must be carried on less efficient units, by 0.00125. The actual figure approximates one-half cent per kilowatt-hour.

Load Carried by the Sanitary District Plant

On the Sanitary District the night load runs about 21,000 kw. It consists of city lighting and some pumpage. The day load approximates 13,000 kw., consisting of commercial power service and electric pumping in some of the water-works stations. It will be noticed that the lake level is lowest during the winter, when the hours of lighting are the longest. Although the seven 4000-kw. units installed are maintained in operation, the available water supply is not sufficient to carry the 21,000-kw. load without lowering the level and reducing the head, so that time must be given during the day for restoration in the limited storage available. A night load then of 21,000 kw. and a day load of 13,000 kw., or an average of 17,000 kw. for the 24 hours, has been the

maximum during the winter that the available water would care for. In the summer months, when the lighting periods are shorter, it would be possible to carry a heavier day load, and it is this surplus that the Edison is to get. Depending on the water available, some 4000 kw. may be supplied for varying lengths of time—on some days perhaps for two or three hours and on other days for eight hours. It will be the surplus available that will prevent waste of water over the dam.

Another complication is that during the winter the night and day loads overlap for a short period, causing a high peak, which has been cared for in the past by a 4000-kw. turbo-generator set in the Thirty-Ninth Street Sewage Pumping Station, where there is plenty of reserve boiler power to handle storm water in addition to the usual amount of sewage. A couple of old city steam stations, the H. N. May and the Washington Park plants, are also available in case of emergency.

As a means of saving some additional coal it has been suggested that the Edison take care of this winter peak. As it is simultaneous with the Edison peak, a higher rate would probably be asked than for the off-peak surplus from the Sanitary District. No definite arrangements on this point have been made, and if later on an agreement is not reached, the same reserve steam units are still available.

Renewing a Water-Tube Boiler Header

By S. P. Black

REPLACING a sinuous header in a water-tube boiler is a comparatively simple proposition, but some of the essential details are so important, that, should a few be overlooked or mismanaged, considerable trouble or failure might occur. The writer having had occasion to do work of this kind at various times, a brief description is given which should be sufficient to

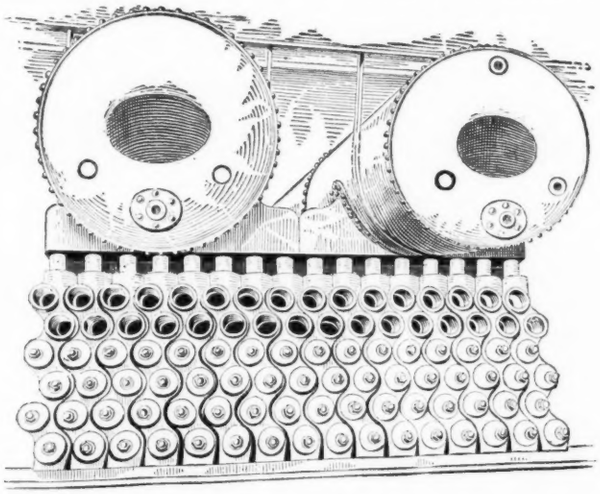


FIG. 1. DOUBLE-DRUM BOILER SHOWING HEADERS

enable one to undertake a similar job with confidence. Although boilers using the sinuous header are of various designs, single-, double- and triple-drum, one- and two-story, cross-drum, vertical and inclined headers, the same principle is applied in any case.

Fig. 1 represents a common type of boiler of the double-drum, vertical-header type with forged steel headers, and it is to the replacing of these latter that consideration is to be given.

Up to 160 lb. pressure, cast iron is used in these headers. As a rule, when a cast-iron header is to be

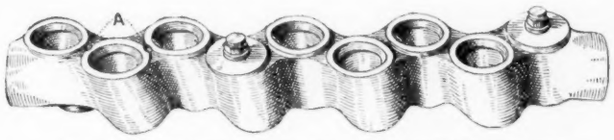


FIG. 2. HEADER DRILLED FOR BREAKING UP

replaced, it is on account of cracking or the destruction of the joint around the caps and no attempt is therefore made to save them and it is not at all necessary to take them out in one piece. The net section or bridges are therefore drilled as shown at *A*, Fig. 2, a tapered pin driven in the hole and the header broken in pieces and removed in sections.

With the wrought-steel header, however, no such expedient would likely be successful, and in addition, the header will in all probability have to be used over again and it is then necessary to remove the whole section in one piece.

Fig. 3 shows the various stages of treatment of individual tubes. *D* represents a section of firebrick that has been rounded up to fit the tube hole. Where

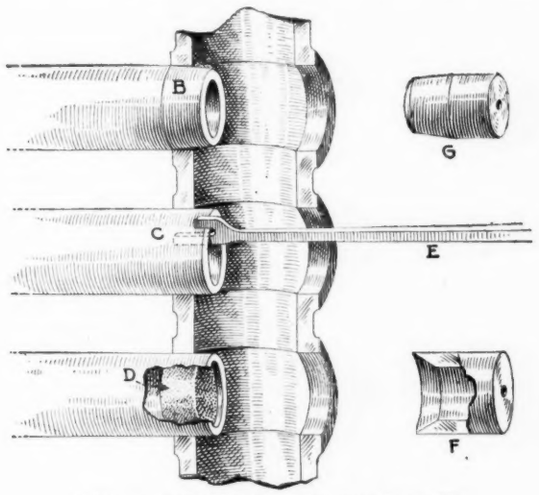


FIG. 3. CRIMPING THE TUBE ENDS

the tubes are very brittle or crystallized, they will all have to be annealed at the ends where they extend through the header and at the bearing of the joint. This also helps to break the joint, but in most cases it is not necessary to heat and insert brick.

The crimping tool *E*, shown in place in the tube *C*, is the most important tool used; the depth of the jaw, length of the foot and the nicety of fit and adjustment are important. The illustration shows all that is required, but it may take some careful fitting and filing to secure the accuracy which, when obtained, will easily crimp the end of the tube all the way around as shown at *B*. The length of the arm of *E* need not be over 18 inches.

After the whole row of tubes has been crimped as shown at *B* and the nipples or risers are cut loose from the drum or saddle, a rope should be passed through a couple of handholes and made fast overhead

by a couple of turns in order to facilitate lowering, for as soon as a man butts the bottom end from the furnace side with a light timber, the whole header comes loose.

The tube baffles will hold up the tubes so that there is no danger of their falling or springing and causing a leaky joint at the other end.

Replacing a header is a simple matter. All the tubes have to be annealed and swaged. After annealing each individual tube with hot firebrick and while the tube is still hot, the tapered pin shown at *G*, Fig. 3, is driven into the hole to round the tube up and restore its normal diameter. The cup swage shown at *F* is also used for the same purpose, a small hole being tapped in the bottom of each in which a rod is screwed to facilitate handling. Swages and pins may be made or turned from extra-heavy pipe that has been properly forged.

After the tubes are opened out to their normal diameter and annealed, it will be found that strains in the baffle plate, warping of the tubes or other strains will have drawn the individual tubes out of alignment so that they will not all come fair when the header is drawn up to position. For this reason, if the tubes are clean and the setting does not prevent, the new header is reset in place while the tubes are in condition, as shown at *B*, and the header is driven back some ten or twelve inches until the tube ends are all in the clear, after which they are squared up and the header drawn forward again until its normal position is regained. The nipples or risers, as the case may be, are first set in place. A ¼-in. projection is given at each end and they are then rolled in place; this sets and gives a solid foundation to the header so that the water tubes will be even and set square before expanding.

Water Supply at the Front

Of all the problems that confront the American engineers in France none is of greater interest than the question of adequate water supply, says the Boston *News Bureau*. In a section where water is scarce an allowance of one gallon a man is made; if the troops are advancing at the front under fire this allowance is cut to one-half gallon or less. It is not uncommon for the enemy artillery to destroy one or more water-supply bases. Water pipes leading up to the front are placed with two to three feet of earth cover, and are often laid in zigzag fashion to allow them a certain amount of play for shell disturbance. Canvas tanks are largely used as water bases in the support areas, and barrels are employed in the trenches. In most sectors wells varying in depth from 100 to 250 ft. have been the chief source of supply. In certain localities river water is rendered drinkable by purifying it through a liquid chlorine apparatus.

Oakite Waste Cleaner

Thrown on the coal pile and burned is what generally becomes of waste and rags used about the power plant for wiping purposes. Much of this material could be saved for future use if a suitable method could be utilized in cleaning it from the oil and grease. Realizing that such used wiping material is being destroyed as unfit for further use, the Oakley Chemical Co., 22 Thames St., New York City, has developed a process whereby this waste can be prevented.

For small plants the system consists of a tank, Fig. 1, in which about 40 lb. of the material to be cleaned is placed, with about 25 gal. of warm water. To this quantity 2 lb. of what is termed Oakite is added and allowed to dissolve. The water is then brought to a boil for 15 min. As the result of this process the oil

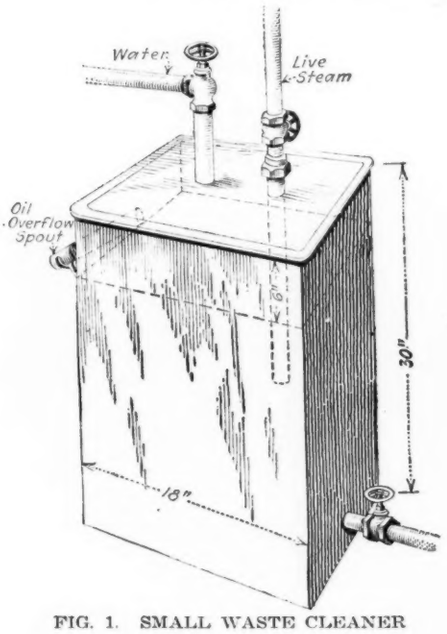


FIG. 1. SMALL WASTE CLEANER

is liberated and rises to the surface of the water, and may be reclaimed by filling the tank with water until the oil runs out of the overflow. When no more oil escapes from the waste, the washed material is rinsed in a separate tank, and, after drying, is fit for use again.

For plants where large quantities of waste or rags are

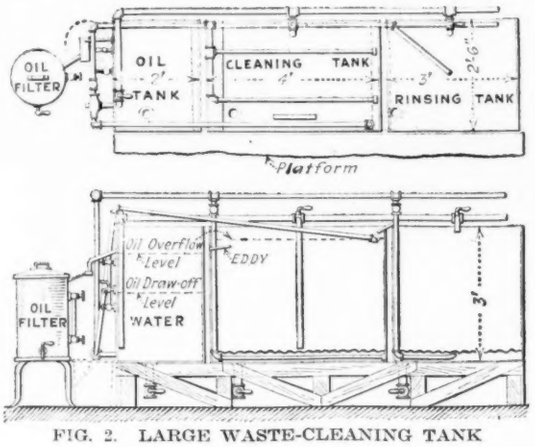


FIG. 2. LARGE WASTE-CLEANING TANK

to be cleansed, the tank shown in Fig. 2 has been designed. The operation of cleaning the material is, however, practically the same as with the small tank.

The Oakite solution can be used over and over again. It emulsifies the oil, but there is no chemical action in so doing. It costs on the average three-quarters of a cent per pound of material cleansed, and the process can be repeated until the material is worn out.

A 25,000-Kw. Turbine Is Damaged in New West End Station

ONE of two 25,000-kw. single-cylinder impulse turbines in the new West End Station of the Union Gas and Electric Co., of Cincinnati, Ohio, was badly damaged in its 17th (last) stage at 9 a.m., Wednesday, Sept. 4. The turbine room of this plant is shown in Fig. 1. The 17th diaphragm shows evidence of having distorted at top and bottom, causing the wheel blades to rub the diaphragm buckets, crushing and burning them, and also burning off the upper side of all blades on the 17th wheel. The speed is 1800 revolutions per minute.

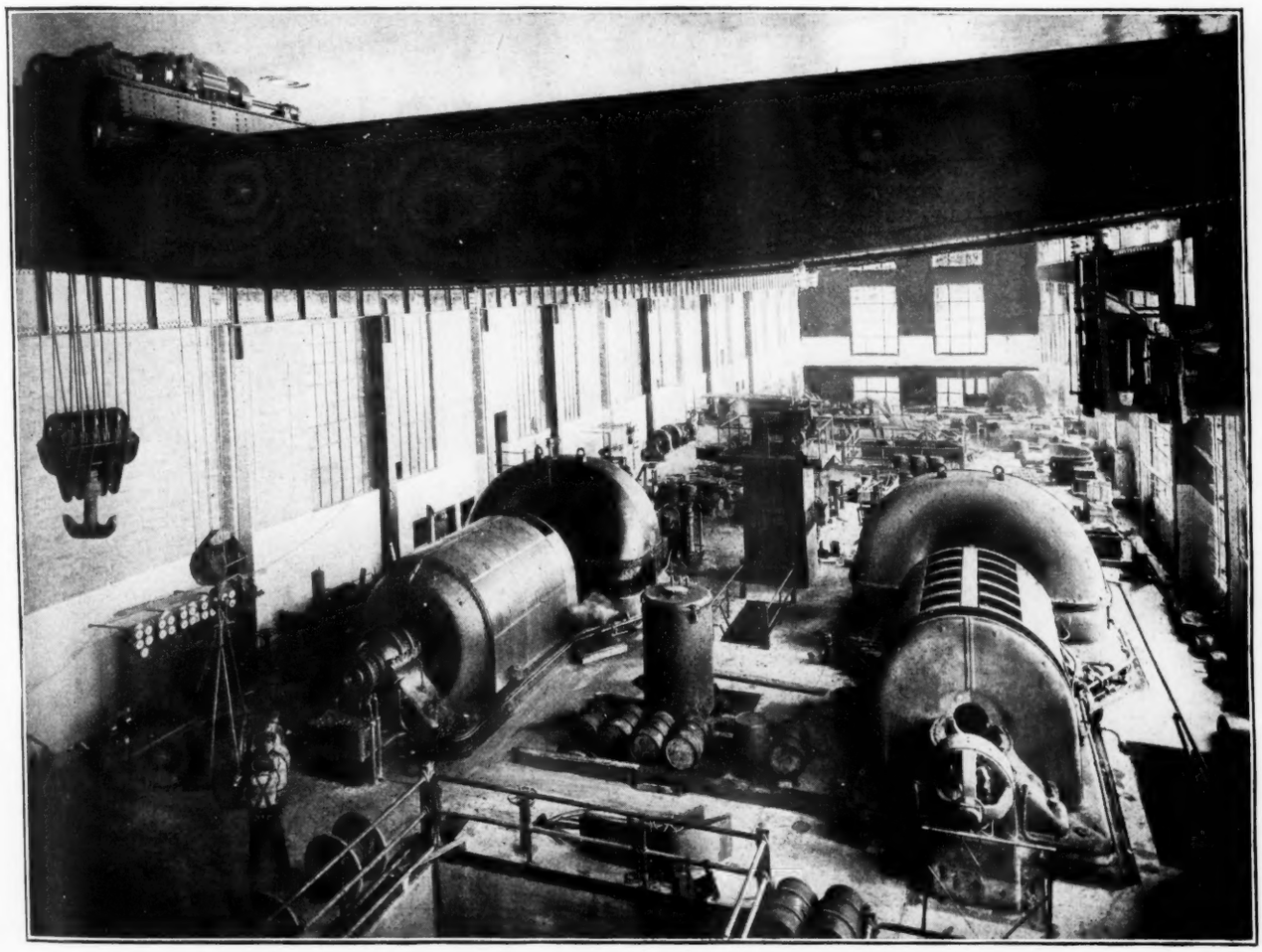


FIG. 1. VIEW OF TURBINE ROOM DURING ERECTION

This turbine, which is of the same general design as that of the 35,000-kw. single-cylinder type, had been installed about two months. It had been satisfactorily carrying trial loads frequently during this time. On the Tuesday morning before the accident the machine was started at 8 a.m., carrying 12,000 kw. all day. At a little before 9 a.m. Wednesday the erecting crew had about 20,000 kw. on the turbine, which carried the load well. There was no alarming vibration or sign of serious rubbing. At 9 a.m. there was a loud bang inside the casing, followed by others accompanied by violent vibration which shook the station. The throttle was immediately tripped, but the noise and vibration continued, much modified, until the machine slowed down to about 700 r.p.m., when vibration and noise ceased and the speed decreased normally.

The condenser wells are 85 ft. deep in this station, and the shrouding for the blades of the 17th wheel, also some of the blades, fell into the long exhaust pipe. The turbine is damaged only in the 17th, or last, stage.

A member of *Power's* staff saw the 17th diaphragm when it was lifted out and the two halves placed together on the floor. Its warped condition is plainly apparent. There are approximately 350 buckets in this diaphragm, and all but eleven are burned or crushed. The bottom and top halves rubbed badly over an arc of about 3 ft. at both the extreme top and bottom. The bottom half rubbed harder than the top half. The projection of the annular ring where the buckets are fastened in and which is near the key or fastening of the diaphragm, took the severest of the rubbing; the metal of this projection is rubbed away over the 3-ft. arcs mentioned to a depth of nearly half an inch. Other projections at these points made less severe contact.

The blades on the 17th wheel are 28 in. long and

are of steel, and have a shrouding over their tips, but use no rosary fastening. There are about 200 blades on the wheel. It is peculiar that about every tenth blade broke off immediately above where it was fastened onto the wheel; 20 blades broke in this manner, breaking clean and sharp, as shown in Fig. 2.

All the blades which remained on the wheel were burned away at their top edges, as shown in Fig. 3. The projections on the tips of the blades do not appear to have rubbed; they merely show the effect of having the shrouding pulled away from them.

It is difficult, if not impossible, to tell the exact sequence of events. However, the machine did not overspeed, neither did it take on load suddenly or warm up suddenly. Just before the 17th stage let go the switchboard operator noticed that the load increased from 20,000 to 22,000 kilowatts. That distortion of the diaphragm was the primary cause of the trouble is indicated by the fact that the projections on the 16th diaphragm top and bottom show signs of rubbing on both halves. The 17th diaphragm is about 11 ft. in diameter over all and the rim speed of the disk is about 1000 ft. per second. The turbine was closed up after the removal of the damaged disk and was in operation on the Monday following, or five days after the accident. It could have been put back in service sooner had it not been kept oopen for the inspection of the engineers of the builders.

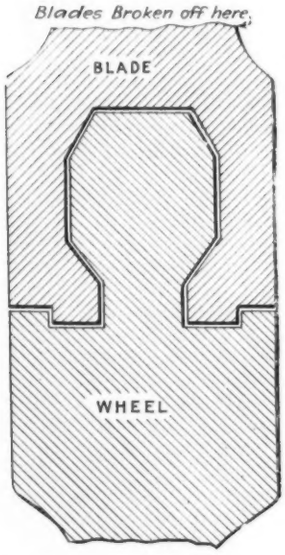


FIG. 2. WHERE THE BREAK OCCURRED IN TWENTY OF THE BLADES

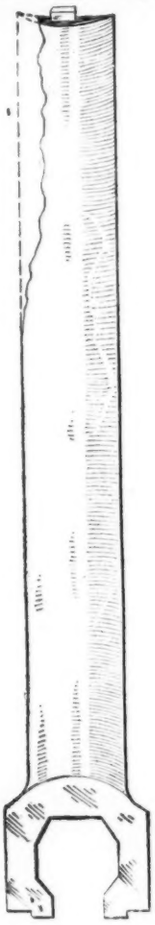


FIG. 3. HOW BLADES REMAINING ON WHEEL WERE BURNED AWAY

The production of bituminous coal for the week ended Aug. 24, passed the 12,000,000-ton mark, being estimated at 12,603,000 tons, an increase of 669,000 net tons over the previous week. Anthracite production for the week was 2,134,000 net tons, against 1,924,000 tons for week of Aug. 17, a gain of 1.9 per cent. This compares with 1,988,600 tons for the corresponding week of 1917.

What Your Subscription Means

When you subscribe to a Liberty Loan you subscribe to the sentiment that the world must be made safe for democracy and subscribe to the fund that is to make the world safe for democracy.

You subscribe to the belief that innocent women and children on unarmed ships shall not be sent to the bottom of the sea; that women and children and old men shall not be ravished and tortured and murdered under the plea of military necessity; that nurses shall not be shot for deeds of mercy, nor hospital ships be sunk without warning, or hospitals and unfortified cities be bombed or cannonaded with long-range guns.

You subscribe to the doctrine that small nations have the same rights as great and powerful ones; that Germany shall not force upon the world the dominion of her military masters.

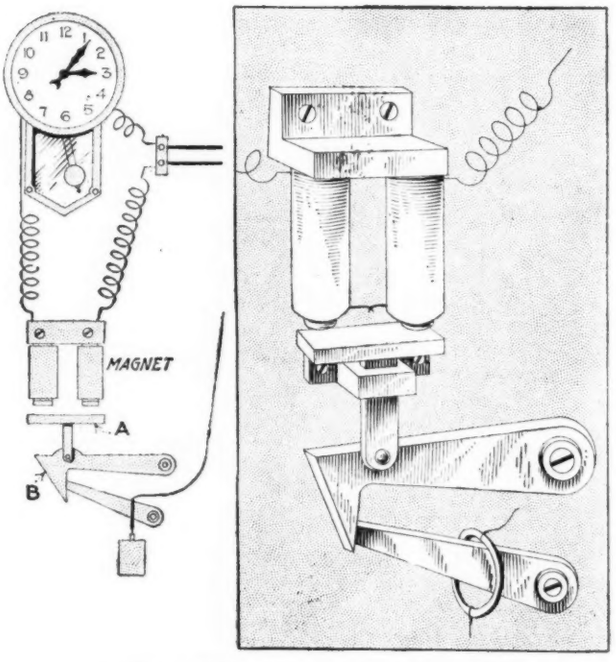
You subscribe, when you subscribe to a Liberty Loan, to the belief that America entered this war for a just and noble cause; that our soldiers in France and our sailors on the sea are fighting for right and justice.

And you subscribe to the American sentiment that they must and shall be powerful, efficient, and victorious.

Automatic Whistle-Blowing Rig

BY WILLIAM H. WATSON

If the engineer is busy with other things he sometimes fails to blow the whistle at the proper time, and as in most shops the men start and stop work when the whistle is blown, it is important that it be done on time. The illustration shows a solenoid trip for a weight on the whistle cord. At whatever time the whistle is to be blown the clock closes the circuit, actuating the magnet which lifts the plate *A* and hook *B*, releasing the weight.



WEIGHT RELEASED BY SOLENOID ACTION

The same kind of trip can also be used on a push-button alarm, engine stop or any apparatus of the kind.

EDITORIALS

The Voice of Liberty

THE war has now entered upon its fifth year, and the end is not in sight. But at no time in all the four long years of swiftly changing fortunes have the prospects for an Allied victory seemed so bright or so certain of realization. And while it would be ungenerous and ignoble to fail to recognize the masterly strategy of Marshal Foch and the heroism and self-sacrifice of the French, British, Italian and Belgian troops, nevertheless it has been due in great measure to the support of the United States that the tide has turned on the Western front and is flowing eastward.

America, the chief exponent of liberty and democracy, made her power felt just at a critical moment. The Germans had overrun a vast section of French territory, sweeping the Allied armies before them, until they stood almost at the gates of Paris. They paused to gather their forces for the final blow—confident, arrogant, boastful, puffed up with pride and drunk with success. But when that blow fell it met an anvil of resistance. At Chateau-Thierry, in the direct line of the advance on Paris, the Huns met the Americans squarely—met them, fought them and were hurled back by the very fury and impetuosity of their onslaught.

The effect of that engagement was electrical. It disposed, once and for all, of the bugaboo that the Hun was invincible; but more than that, it showed the harassed and war-worn Allies the splendid courage and the indomitable fighting qualities of the American troops. From that moment to this, the American soldier has been giving daily proof of his dependableness, his resourcefulness and his determination to win. And with the knowledge that there were a million like him in France, and millions more in training or waiting to be called into service, the spirit of our Allies was cheered and heartened. And as a result the Germans have been driven back, mile by mile, to the positions they held before their victorious rush of last March.

America's part in this splendid achievement represents a vast outlay of treasure. The outfitting of troops, their transportation and their supplies of food and ammunition have cost enormous sums—figures that are beyond comprehension. And our great work has only been well begun. The cost has been tremendous, but it will not grow smaller. During the past month our war expenses averaged more than fifty million dollars a day. But America has pledged herself to win the war, and even the swiftly mounting billions of debt cannot swerve her or distract her from her lofty purpose.

It is no longer a mere war of sentiment or of retaliation for countless insults and provocations. It is a conflict in the issue of which is bound up the existence of national liberty and freedom. We are fighting now to preserve for ourselves, as well as for all the rest of the world, those principles of justice and liberty on which our mighty nation is founded.

For the preservation of such rights and privileges as these, no cost is too high, no sacrifice too great. The artist who drew the colored supplement accompanying this issue has attempted to convey something of this impression. Liberty is endangered by the encroachments of a hateful autocracy, and she is making an appeal to lovers of freedom to establish her firmly and unalterably.

Billions are needed now and will be needed in the near future, and the burden of supplying them rests on the people of America. It is not an impossible task—nothing is impossible to a united nation animated by a single purpose. But it means the practice of self-denial on the part of every individual, the pruning of personal expenditures, to lend to the nation.

The voice of Liberty speaks, and the message is as plain as your duty.

How clearly have you heard the call?

Coal or Cars: Which?

A FEW days ago Director General of Railroads McAdoo, in his report to President Wilson, said that car shortage had not been responsible for the fact that the coal mines had failed to produce their maximum output. This was somewhat reassuring in that every coal user was fearful that last winter's experience, due in a measure to the lack of railroad transportation, was to occur again this winter.

Hardly had the public been told that the railroads were in a position to handle all traffic demands, when the National Coal Association took issue with Mr. McAdoo's statement as follows according to the New York *Times:*

> Shortage of railroad cars at the bituminous coal mines of the country has curtailed production not less than 82,000,000 tons since January 1 last, and stands as the dominating factor of all causes of curtailment. Much of this huge production lost to the country, because the railroads did not furnish the coal mines sufficient cars, occurred during the months of January, February, and March, when the railroads were recovering from the worst congestion in their history and from the effects of unprecedented storms.
>
> Car shortage cut bituminous coal production 1,934,000 tons during the week ending August 17; 1,559,000 tons during the week ending August 10; and 1,145,000 tons during the week ending August 3. These figures do not support a claim that the coal mines are receiving more cars than they can load, even recently.
>
> The production of bituminous coal from January 1 to August 24, inclusively, totalled 384,000,000 tons. The mines that produced this coal were capable of producing 522,000,000 tons under full time output. The total production lost from all causes was therefore 138,000,000 tons—far more than enough to afford a guarantee against a fuel shortage. Here are the reasons why these 138,000,000 tons were lost:
>
> Because of car shortage, 82,000,000 tons; because of labor shortage and strikes, 22,750,000 tons; because of mechanical disabilities and unavoidable shutdowns at the mines, 19,750,000 tons; because of no market (chiefly in Southwestern States) 4,000,000 tons; all other causes, 9,500,000 tons.

Next comes a statement from the office of Director General McAdoo that the figures published by the National Coal Association were misleading as they do not take into account many situations which arose from time

to time. For instance, that if a mine that had produced a certain amount suddenly increased its output, the lack of sufficient cars at the mine was put down to car shortage, although the railroad administration had had no warning in advance that the additionl cars would be needed.

It seems to be a case of Katy did and Katy didn't. Whatever the cause of the present lack of coal production, the consumers have to stand for the shortage. If both the National Coal Association and Director General McAdoo are positive that the blame rests with the other party, it would seem that the matter could be brought to a focus by Mr. McAdoo by delivering more cars to the mines and so compel the mine operators to produce the coal or admit that they cannot fill all the cars that are provided them.

If, on the other hand, more coal is being mined than can be loaded and hauled because of lack of cars or locomotives, they can make Mr. McAdoo see the point without much trouble, it would seem. If a report were sent to the Director General at the close of each working day, of the additional tonnage that could have been shipped by each operator had the cars been supplied, it is more than probable that sufficient cars would be forthcoming if it were possible to get them.

This placing the blame on the other party does not get anywhere. Either there are sufficient coal cars provided or there are not. Either the mine operators are mining all the coal that can be loaded into the cars or they are not. If more coal could have been shipped than has been, the fault rests either with the production or with the transportation. Which is it: coal or cars?

How Every Employer Can Help

ON PAGES 68 and 69 of this issue is the announcement of a plan in which under an organized method the coöperation of every employer is requested in order to help in the promotion of the Fourth Liberty Loan. That announcement is worthy of careful and immediate attention and action. It is certainly not difficult to see how the energetic carrying out of this plan may produce results helpful not only to the Liberty Loan but to American business.

The tremendous impetus which Charles M. Schwab has given to shipbuilding has been largely achieved by making every individual engaged in the industry feel a personal responsibility for results and a personal pride in helping to make great results possible. This spirit of accomplishment in the shipbuilding industry has been brought about by the leaders—the employers—making it a business to come in personal contact with the workers and to inspire and enthuse the men with a sense of the importance of their work for victory in the war—a sense of personal responsibility, and a spirit of teamwork.

The creation of that spirit among the workers of the nation in all lines of activity would be of incalculable benefit to the workers themselves, to employers, and to the nation. Concretely, two of these results would be: To quicken and increase the response to all war measures such as Liberty Loans, War Saving Stamps, the draft, food and fuel saving; it would make the worker feel more keenly his responsibility to do his work (no matter what its character) to the very best of his ability—make him feel the necessity of sticking closely to his job.

Employers generally should pursue with intelligent enthusiasm the plan of "Win-the-War" meetings proposed as a means to aiding the rapid flotation of the Fourth Liberty Loan. The results of such action will not only be helpful in the Loan drive, but will be permanently helpful to the nation through the development of a keener realization by the worker of the importance and dignity of his individual job and the necessity for personal responsibility and helpful teamwork.

Good Night, Garabed

IN AN attempt to satisfy the curiosity of some of our readers as to what occurred at Garabed Giragossian's attempted demonstration of his ability to make available unbounded "free energy," a correspondent of *Power* called upon Mr. Giragossian, Professor Moyer, the chairman of the committee chosen by him and approved by Secretary Lane to pass upon the practicability of his invention or the value of his discovery, and Professor Miller, of the Massachusetts Institute of Technology.

Mr. Giragossian told the correspondent that he had never completed a machine that would deliver power in any real quantity, but expects to accomplish this in seven or eight weeks. He told the editor at Washington, while his bill was before Congress, that he had a machine that he had run innumerable times; once continuously from eight in the evening until two in the morning; that he could start and stop it at will, that it was still in existence, its parts locked up in several safes, but that it could be collected, assembled and run to the satisfaction of any committee in ten days at the most. He told our correspondent that he did not demonstrate a complete machine to the committee because he feared he might lose control of his invention or discovery.

Professor Miller said that Mr. Giragossian did show a model to the committee; that he had mixed static and dynamic principles in his mind and that of the hundreds of perpetual-motion machines that he (Professor Miller) had seen this was the most foolish of all.

Professor Moyer said that the model shown was a combination of pulleys and gearing by which force was multiplied through leverage and apparently only a part of the apparatus upon which Mr. Giragossian is working. Force, however, is only one factor of energy and can be multiplied only at the expense of the other.

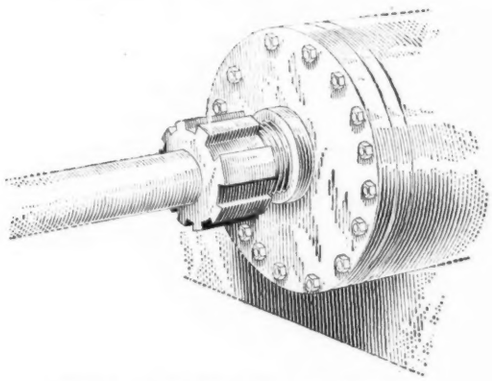
In his representations to Congress Mr. Giragossian did not commit himself sufficiently to warrant one in condemning his proposition out of hand. He simply claimed to have made a valuable discovery and offered to demonstrate it at his own expense and to give the Government the free use of it if he could be protected in the control of other than governmental use. There was not one chance in a million that he had anything, but under the conditions Congress could do no less than to give him a chance to demonstrate his idea. No charge of credulity or of taking him with overseriousness lies against those who voted to do so or the engineers who passed upon his attempted demonstration.

What needs demonstration now is whether Mr. Giragossian was actuated by honest self-delusion, plain lunacy or a purposeful intent to deceive.

CORRESPONDENCE

Slotted Stuffing-Box Gland Nut

The slotted type of stuffing-box nut sometimes used on small pumps calls for a special spanner wrench to turn it, and in the absence of the spanner a hammer and blunt chisel are probably the tools used with disastrous results as to looks at least. Is there any valid reason why a slotted nut should be used where a



FORM OF GLAND NUT OBJECTED TO

hexagonal nut will serve? Locomotive fittings such as injectors and other pipe unions are often used with union nuts of the slotted variety where room is limited, but the spanner made for the job will often slip, resulting in "barked" knuckles. From a production point of view there seems no advantage in favor of the slotted nut. It is to be hoped, in the interest of the operating engineer, that this design will soon disappear.

Tooting, London, S. W., England. A. L. HAAS.

Appreciates Inspector Brown's Visits

Referring to the criticisms of the "Visits of Inspector Brown" articles, by Mr. Forbes and Mr. Revere, I would like to say that I have read this series from start to finish and have found it valuable to me. Where there is any danger at all of an explosion in any equipment, it should be pointed out and articles such as the "Chief" writes are, I am sure, greatly appreciated by a large number of *Power* readers.

Anyone who has had the care of economizers knows that in putting one on the line, if all the air is not removed and the hot gas is allowed to come in contact with the tubes, there is a chance that they will become heated to a much higher temperature at the top than the part that contains water and the headers may come off or the tubes may fail. A hot fire under a fire-tube boiler containing cold water is likely to start seams, tube ends and stays leaking badly and put a terrible strain on the whole boiler, but the boiler probably would not fail because the steel of the boiler will permit considerable expansion.

In regard to calling the tubes, "nipples," I look upon this matter as an exaggerated illustration. I suppose the "Chief" could have used the expression of push tubes and it would have caused no comment.

As to Mr. Revere's statement that "there is not a case on record of an explosion of an economizer when operated at what we consider high pressures these days," there have been explosions in economizers with moderate pressures and there is still a chance for an explosion with higher pressure and this is a point the "Chief" wishes to bring out. I think it would be good to have an article about the dangers of gas explosions in economizer settings, which I believe are not uncommon. HOWARD H. WHITAKER.

Somerville, Mass.

Handy Packing Cutter

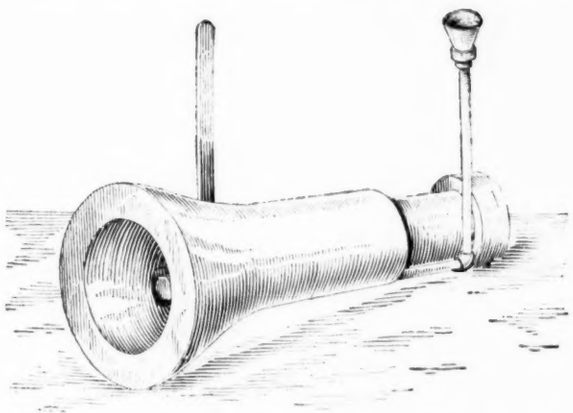
An old plug tobacco cutter (or a new one for that matter) makes a good tool to have in the engine room, for cutting all kinds of packing for stuffing-boxes and pump plungers.

A. H. HALLADAY.

Spring Valley, Ill.

Cure for a "Balky" Hydraulic Jack

In attempting to use a hydraulic jack to force a new crankpin into the crank disk of an ammonia compressor we found that the jack would not work when placed



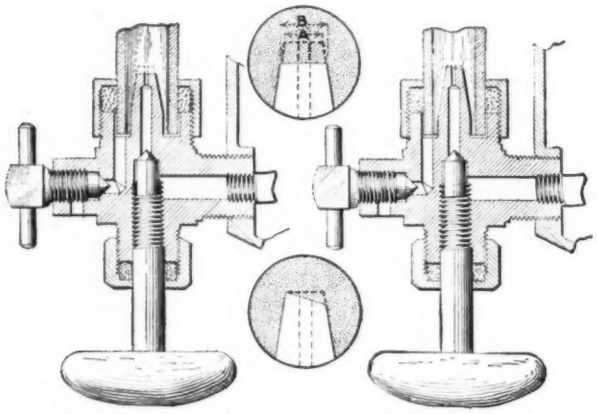
PIPE TO CREATE A HEAD OF FLUID IN THE JACK

in a horizontal position, although it should, of course. I reasoned that if the valves and plunger could be kept covered with oil (oil was the fluid used in the jack) it would "have to work," so I removed the vent plug from the top of the oil reservoir and connected a ¼-in. pipe to the opening as shown, giving the oil some "head" pressure, which kept the valves covered, and the jack went to work immediately as well as when in a vertical position. J. F. POTTS.

Fort Pierce, Fla.

Hydrostatic Lubricator Regulation

Of course everyone who has ever used a hydrostatic lubricator knows how to regulate the number of drops of oil fed per minute, but many have forgotten, and perhaps more never have known, how to vary the size of the drop. This is done by slightly changing the



FILING THE NOZZLE OF SIGHT-FEED LUBRICATOR

end of the nozzle. If a larger drop is desired, file off the end of the nozzle as shown in the first illustration.

This gives a greater area across the end as at *B* for the same size of opening in the nozzle, and the result is a larger drop. The reason for this is that a drop of oil forms on the end of a pipe or nozzle because of the adhesion between the oil and the metal on the end. The drop breaks off and floats up through the water because the buoyancy becomes greater than the adhesion. With more surface at *B* for the oil to adhere to than at *A* more buoyancy, and hence a larger drop is needed before it will break off and float upward.

When a smaller drop is desired, it is a simple matter to file the end of the nozzle to a sharper point so that less surface remains on the end.

Care should be taken to file the nozzle evenly. If filed unevenly, as shown in the second illustration, the drops will travel up at an angle, hit the glass and follow it, and thus soon fill the sight glass with oil.

Chicago, Ill. A. L. NOE.

Emergency Water Supply for Bearings

Many problems arise in the solution of which a great deal of thought and ingenuity is used and the experience of most engineers proves that there is always another way to accomplish a desired result outside of the existing order. The following incident is a case in point:

In a certain hydro-electric plant the waterwheels, mounting two runners on the shaft and operating under a twenty-foot head, ran on lignum vitæ bearings, lubricated by water, through a one-inch pipe tapped to the city water main. At one time the water supply was interrupted and water had to be secured by some other means to supply these bearings. The installation consisted of four wheels set in separate pits, but only two of the wheels were running, and by shutting off the valve connecting the supply pipe to city pressure, the water from the idle wheel pits was drawn through the bearing by suction in the draft tube of the machine running and a continual flow was kept up by the siphon thus established. This settled the difficulty until the regular supply was available.

Richmond, Va. J. M. PURCELL.

Improvised Feed-Water Heater

The illustration shows the general arrangement and details of a feed-water heater of the "home-grown variety" that is in operation in a small plant having two horizontal return-tubular boilers, a duplex boiler-feed pump and a 90-hp. Corliss engine belted to an a.c. generator. Originally the 6-in. exhaust pipe from the engine passed out through the wall and horizontally, as shown in dotted lines, to the bank of the creek on which the plant is situated. The pump draws water from the creek and in the first arrangement pumped the feed water directly into the boilers through a 1½-in. pipe, also shown dotted.

As the plant is operated only during the summer months, the management could not be induced to buy a feed-water heater, so the engineer decided to make one that would save at least a few B.t.u. The exhaust pipe was shifted to the inside of the boiler room, with a 6 x 6 x 4-in. tee near the wall between the engine and boiler rooms, as shown by the full lines. The discharge

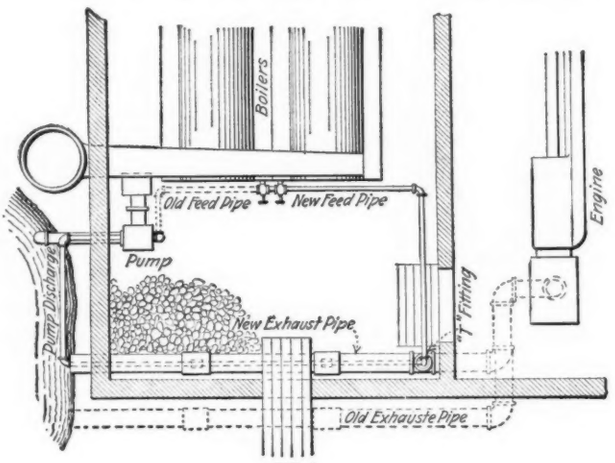


FIG. 1

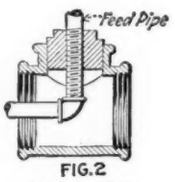


FIG. 2
Detail of "T"

FIG. 3
Manner of Supporting Feed Pipe Inside Main Exhaust

FIGS. 1 TO 3. BOILER FEED PIPE PLACED INSIDE ENGINE EXHAUST

Fig. 1—General layout of the plant. Fig. 2—Detail of feed pipe through a tee. Fig. 3—Support of feed pipe inside the exhaust pipe.

pipe from the pump was changed to the opposite side of the valve chamber, run out through the wall and then turned back, so as to enter the open end of the exhaust pipe, and it runs inside this to the tee fitting, where it passes out and is connected to the old boiler-feed line. The details of the tee fitting are shown.

The feed pipe is supported inside of the exhaust line near the couplings by a couple of short lengths of 1½-in. pipe wired together so that the exhaust passes through freely and the back pressure on the engine seems to have

been increased but little if any. About the only new material used in making the heater was the large tee and the additional length of feed pipe. The heater is probably not very efficient, as it has so little heating surface, but it helps some and shows a commendable desire on the part of the engineer to save fuel under unfavorable conditions. HUGH G. BOUTELL.

Washington, D. C.

Effect of Intermittent Boiler Feeding

An apparatus that gives satisfactory results under certain conditions will not always do so under other conditions. For instance, the following relates to two cases of feed-water regulation in power plants where I have been employed.

My first experience was with what is termed the intermittent-flow feed-water system in a modern plant where the boilers were equipped with steam-flow meters, balanced-draft machines, etc., but it was soon evident that the intermittent flow of water to the boilers interfered with many of the results expected of this equipment.

The primary idea of the steam-flow meter was to show the fireman, by the steam flow, whether he was carrying the right kind of a fire; but when the regulator closed, and no water was going in, the boiler did a very high rating, and a few minutes later, when the regulator opened, the output dropped to practically nothing; therefore, as a firing check the meters were useless.

The balanced-draft machines, controlling the position of the stack dampers, were supposed, in conjunction with the steam flow, to check the amount of air going through the fire, but under the existing conditions did not fulfill their purpose. The feed-water regulators were afterward changed to the constant-flow type, with the result that in this plant the full boiler equipment was used to its best advantage.

The next experience with this type of regulator was in a large mill plant, which contained over ninety boilers of several kinds. The feed water was taken from the river, and during certain seasons of the year, when the river was low, the water contained a large amount of acid and required a great deal of soda to counteract it. During these periods, for years back, it has always been hard to hold steam, which, for no apparent reason, would drop from 130 to 90 lb. in a few minutes, causing mill delays and other troubles.

My explanation of this trouble is that the large amount of sodium carbonate in the water has a tendency to cause priming, especially when pushing the boilers at high ratings. Then assuming that the steam is up to 130 lb. pressure and everything going along nicely, a large mill starts up and pulls the steam down about ten pounds. Reducing the pressure on all the boilers at the same time causes a large amount of stored heat in the water to be transformed into steam, causing the water to boil violently, and, being filled with steam bubbles, rises about five inches in the glass, and the flow regulators shut off the feed.

As the water evaporates it gradually comes down until it reaches the center of the glass, still filled with steam bubbles, when the regulator opens a stream of comparatively cold water into the boiler, and almost instantly the steam bubbles disappear, and the water drops to the bottom of the glass. The regulator then stays open until the center of the glass is again reached, and during this time the heat of the furnace is used in heating water rather than in making steam, and the pressure drops rapidly. At this point, however, the feed valve again closes and the steam pressure increases, and the same operation is repeated.

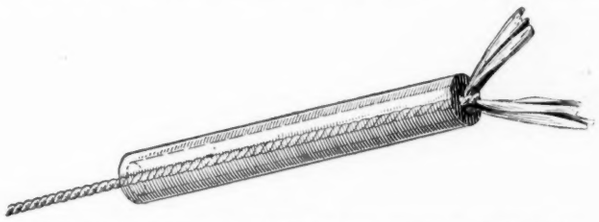
The whole story in a nutshell is that the tendency of water with a high soda treatment to prime, is aggravated by the type of regulator mentioned, while it is retarded by a constant flow of water.

The efficiency of the plant is also affected by the high demand for heat from the furnace while the boilers are taking water, as the best economy can be obtained only by keeping the conditions as nearly uniform as possible, such as constant load, constant draft, constant coal feed and constant water feed.

Pittsburgh, Penn. J. F. TUTEIN.

Cleaning Gage-Glasses

The matter of keeping gage-glasses clean is of great importance because otherwise it is quite possible to misjudge water levels. If the cause of the clouding is oil, it can be readily removed with chloroform or



AVOIDING INJURING GAGE-GLASS WHILE CLEANING

other solvent. One of the most important points to bear in mind in cleaning gage-glasses, especially those used under high pressure, is to avoid scratching them with some sharp implement, such as a wire. Therefore, wood should be used to carry the wiper or, better still, a small piece of chloroform-soaked rag can be tied to the end of a piece of cord, dropped through the glass, and used to pull the rag through. Carelessness in cleaning or inserting glasses is the cause of a great many "mysterious" breaks. Care should also be taken in replacing glasses to see that they are not left in a strained position and that good live packing is used to permit expansion and contraction.

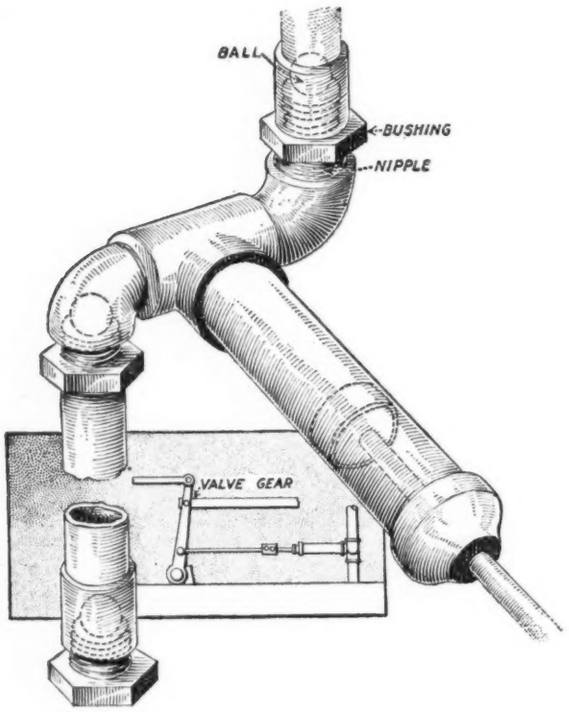
Philadelphia, Penn. M. A. SALLER.

Large Saving by Re-use of Oil

Under the old regime the engine oil was used once only, after which it was allowed to run off in the sewer, and the sewers often had to be "opened" and several times were found completely "choked" with dirt built up on the grease and oil from the machinery. Opening sewers is expensive and in addition the waste amounted to 24 barrels of machine oil per year.

After taking charge of the plant I purchased an oil filter which made a saving, but not being able to arrest all the oil on its way to the sewer, there was

room for more improvement. The oil flowed to the flywheel pit, which was drained through a 2-in. pipe. I made a pan to be set under the outlet end of this pipe; then with a few fittings I made a pump to take the oil from the pan and discharge it into the filter.



OIL PUMP ATTACHED TO VALVE GEAR

The pump was made out of a piece of tube three inches long, three brass bushings, one brass tee and three steel balls from an old automobile wheel, two street ells, two couplings and one close nipple, and it is driven from the valve gear. We now run 24 months on six barrels of oil, which is a considerable saving.

Fort Pierce, Fla. J. F. POTTS.

Bituminous Coal and the Possible Saving

The accompanying table is a compilation by the statistical department of the United States Fuel Administration giving the estimated consumption of bituminous coal by states for 1917, exclusive of coal shipped for railroad, export, foreign and domestic bunker purposes. Through the questionnaire and the resulting improvement in power-plant economy, a saving of 20 per cent. in industrial and electric coal is expected, and there is hope of a saving equally large in the domestic supply. If attained, the saving will exceed sixty million tons and go a long way toward eliminating the estimated shortage.

The ten states first named are the big users of bituminous coal, and it is here that the greatest saving is possible. In proportion to their consumption, however, the other states have an equal chance, and as their number is 37, the total will be by no means insignificant.

A great deal will depend on the coöperation extended by plant owners, their honesty in filling out the various questions and their compliance with reasonable requests for improvement in plant equipment and in operating methods. It is to their interest financially and above all a patriotic duty.

Questionnaires that have been returned are reported to indicate carelessness in some cases and in others a lack of data rather than too much; that is, the answers are not made explicit enough for a ready understanding of the exact conditions. In regard to reports on the tightness of settings and baffles, the warping of doors and the insulation of boilers and piping, the majority of answers indicate perfect conditions. This, of course, is improbable and will be detected when inspectors visit the plant. The interval between, however, may be considerable, so that it means that much time lost and a reduction in the possible annual saving.

The questions contained in the questionnaire are comparatively few and simple. In each plant they should call attention to some one thing, or perhaps several items that may be improved and result in higher efficiency. It is important that these improvements be made voluntarily and at once. A subsequent report to the Administrative Engineer for the state will improve the rating given the plant and will mean more consideration later on when the summer surplus dwindles and it is difficult to meet the demand.

If advice is needed, the administrator will see that it is obtained preferably through a local engineer capable of giving it. When the way is made plain, there should be no need of urging the spending of a little money for improvements, which should be returned many times over by the saving effected in coal. Besides being a personal gain, it is a contribution to a great cause and will have a direct influence on the time required to win the war.

ESTIMATED CONSUMPTION OF BITUMINOUS COAL BY STATES FOR 1917, IN THOUSANDS OF TONS

State	Domestic	Coal Gas	Electric	Industrial	Total	Per Cent
1. Pennsylvania	3,336	30	3,250	36,660	43,276	14.1
2. Illinois	9,721	335	4,250	23,449	37,755	12.3
3. Ohio	4,900	70	3,000	24,755	32,725	10.7
4. Indiana	3,500	155	1,625	16,440	21,720	7.1
5. New York	3,500	650	2,750	12,800	19,700	6.4
6. Michigan	2,974	800	1,250	8,500	13,524	4.4
7. Missouri	3,000	585	700	7,004	11,289	3.7
8. Massachusetts	1,200	570	1,700	7,150	10,620	3.5
9. Alabama	1,300	85	205	9,063	10,653	3.5
10. Wisconsin	3,132	300	650	6,150	10,232	3.3
11. Iowa	2,912	43	915	4,097	7,967	2.6
12. New Jersey	190	90	1,175	4,880	6,335	2.1
13. Minnesota	3,637	125	545	2,214	6,521	2.1
14. Colorado	1,450	.....	420	3,862	5,732	1.9
15. Maryland and District of Columbia	952	21	480	4,190	5,643	1.8
16. Kentucky	1,864	11	410	2,754	5,039	1.6
17. Virginia	906	110	515	2,895	4,426	1.5
18. West Virginia	1,300	2	275	2,989	4,566	1.5
19. Tennessee	1,211	67	350	2,565	4,193	1.4
20. Kansas	1,800	25	200	2,336	4,361	1.4
21. Montana	1,485	11	75	2,335	3,906	1.3
22. Georgia	1,471	75	175	1,600	3,321	1.1
23. Connecticut	200	140	585	2,465	3,390	1.1
24. Nebraska	1,425	.....	475	1,170	3,070	1.0
25. North Carolina	820	44	95	1,602	2,561	0.8
26. Texas	650	13	150	1,588	2,401	0.8
27. Rhode Island	45	120	325	1,500	1,990	0.7
28. Utah	1,079	37	60	698	1,874	0.6
29. Washington	850	97	25	745	1,717	0.6
30. North Dakota	1,155	6	140	400	1,701	0.6
31. Maine	100	80	75	1,158	1,413	0.5
32. Louisiana	570	3	205	566	1,344	0.4
33. Mississippi	600	17	200	428	1,246	0.4
34. South Carolina	480	3	180	615	1,278	0.4
35. Arkansas	300	.....	233	387	920	0.3
36. New Hampshire	90	18	60	900	1,068	0.3
37. Oklahoma	175	1	50	640	866	0.3
38. California	355	0	0	346	920	0.2
39. Delaware	20	1	30	559	610	0.2
40. Idaho	300	9	.....	284	593	0.2
41. New Mexico	240	2	50	257	549	0.2
42. Oregon	325	8	10	167	530	0.2
43. Wyoming	250	23	75	130	478	0.2
44. Arizona	65	.....	55	82	202	0.1
45. Florida	90	3	50	49	192	0.1
46. Nevada	100	.....	90	95	285	0.1
47. Vermont	20	10	35	300	365	0.1
Total	66,045	4,795	28,243	205,923	305,876	100.0

Total for New England States, 18,846,000 tons.

Inquiries of General Interest

Stack's Capacity for Oil Fuel—What boiler capacity should be obtained when using oil fuel with a stack that is suitable for 500 hp. of coal-fired boilers? A. C.

The required cross-sectional area of stacks for oil fuel may safely be taken as 60 per cent. of the area required for coal-fired boilers, and the present stack for oil-fired boilers should be suitable for $500 \div 0.60 = 833$ boiler horsepower.

Advantages of Using Washed Coal—What advantage is to be gained by using washed in place of raw unwashed coal? J. N. S.

Washed coals burn more rapidly than the raw coal and in plants where furnace operating conditions are suitable for the kind and size of coal, washed coal offers a means of running at higher capacity and good efficiency, but in the average hand-fired plant, capacity is gained at the expense of efficiency.

Specific Heat of Brine—What is the specific heat of common salt brine? H. C. D.

The specific heat varies with the strength of the solution as follows:

Per Cent. Pure Salt by Weight	Degrees Baumé at 60 Deg. F.	Degrees Salinometer at 60 Deg. F.	Specific Heat
1	1.0	4	0.992
5	5.5	20	0.960
10	10.7	40	0.892
20	20.4	80	0.829

Double Ports of Duplex Steam Pump—Why are duplex pumps provided with separate steam and exhaust ports? H. J. R.

Separate ports are provided to permit of small valve travel and at the same time give the valve sufficient bearing surface to prevent leakage of live steam from the admission to the exhaust sides of the valve. Separate exhaust ports also afford a simple means of cushioning the piston near the end of its stroke as a result of having the exhaust port covered by the piston before it reaches the end of its stroke.

Air Required for Combustion of Different Fuels—What is the theoretical quantity of air required for combustion of different kinds of fuels commonly used in boiler practice? R. G. B.

The quantity depends on the actual analysis, but for practical purposes the weight of air theoretically required for combustion per pound of different kinds of fuel may be assumed to be as follows:

Illinois bituminous, poor quality	7.0 lb. of air per lb. of coal
Illinois bituminous, good quality	9.4 " " " " " " "
Anthracite, average	10.2 " " " " " " "
Semibituminous, Pocahontas	11.2 " " " " " " "
Liquid fuel	14.24 " " " " " " "

Setting New Gage-Glasses—In replacing broken gage-glasses we often lose three or four out of the same lot of new glasses as soon as they are set in place. What is the probable cause? W. K.

New gage-glasses generally break from being set too firmly to prevent their free expansion or from unequal expansion of material in different parts of the glass tube. A new glass should be allowed to warm up gradually. When put in with the boiler under pressure, the bottom valve admitting water should be opened first and afterward the steam valve should be opened very slowly until the water level of the boiler appears to be correctly indicated, after which the steam valve can be opened wide. In replacing gage-glasses on boilers under pressure, breakage is likely to occur when the greatest care has been observed and the operator should observe precautions against injury from flying glass and from becoming scalded.

Absorption Capacities of Orsat Solutions—What are the absorption capacities of the standard solutions used in Orsat apparatus for analysis of boiler-flue gases? W. R. C.

The solution of 330 grams of potassium hydroxide to 1000 c.c. of water will absorb about forty times its own volume of CO_2 before it becomes too weak for use. The standard potassium pyrogallate solution, when kept sealed and protected from light, can be used for absorption of about twice its own volume of oxygen; and the standard cuprous-chloride solution for testing the percentage of CO can be used for absorption of an equal volume of that gas. For reliable results with any of the solutions they should be renewed whenever they show signs of weakness, regardless of the length of time they may have been in use.

Quality of Steam Too Low for Throttling Calorimeter—What would be the quality of steam at 80 lb. gage tested in a throttling calorimeter discharging to the atmosphere if the thermometer indicated the temperature in the calorimeter to be 212 deg. F.?

Assuming that the steam in the calorimeter was at atmospheric pressure, the temperature, 212 deg. F., was only the same as that of wet or of dry saturated steam at the calorimeter pressure, and as the original steam did not contain enough heat to convert it into superheated steam at the reduced pressure, the quality would be too low for determination with a throttling calorimeter. For finding the quality it would be necessary to employ either a separating calorimeter or some form of condensing calorimeter.

Coal Required by Boiler of Given Capacity and Efficiency—What quantity of coal would be required per hour by a 400-hp. boiler, operated 50 per cent. over rated capacity with 60 per cent. efficiency when using coal that has a heat value of 12,500 B.t.u. per pound? J. H. N.

With 60 per cent. efficiency and 12,500 B.t.u. per pound of the coal, the evaporation would be equivalent to $\frac{12\,500}{970.4} \times 0.60 = 7.728$ lb. of water from and at 212 deg. F. per pound of coal. Considering a boiler horsepower to be equivalent to the evaporation per hour of 34.5 lb. of water from and at 212 deg. F., a 400-hp. boiler, when operated at 50 per cent. over rated capacity, would require the combustion of $\frac{400 \times 1.50 \times 34.5}{7.728} = 2678$ lb. of coal per hour.

Synchronous Motor Would Act as Brake—A straight-lift package elevator-conveyor consisting of vertical uprights and sprockets, over which endless chains operate, is to be driven by an induction type of electric motor. Packages are to be delivered at a bottom floor and discharged at a top floor, or vice versa. In only elevating packages the motor would be working to fullest capacity, but in only lowering packages, the motor would be urged forward by the descending load. When the current is on, will the motor hold the load, or speed up and run away? H. J. B.

The speed of the motor would not exceed "synchronous" speed by any great amount. As the difference between the actual and synchronous speeds seldom exceeds 4 per cent., even at full load, there should be no undesirable increase of speed under any conditions. The moment the load began to drive the motor faster than synchronous speed, it would be converted into a generator and thus act as a brake on the system.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Recent Developments in Condensers*

By D. W. R. MORGAN

Engineer, Condenser Department, Westinghouse Electric & Manufacturing Company

Necessity for efficient air removal in surface condensers. Advantages of hydraulic over reciprocating air pump and the possibilities for land use of the steam air ejector used in marine work. Increasing use of jet condensers for units of large size. Relative merits of steel compared with copper and Muntz metal for condenser tubes.

MANUFACTURERS of condensing equipment have made strenuous efforts to develop a highly efficient air-removal apparatus, not because present types of air pumps have failed, due to the advent of high vacuum, but to obtain the same results with a higher degree of efficiency,

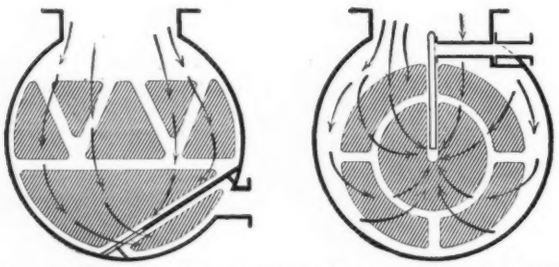


FIG. 1. CONVENTIONAL DESIGN OF SURFACE CONDENSER AND THE RADIAL-FLOW TYPE

and they have discovered that within a certain range of vacuum the steam air ejector has a higher efficiency than any of the previous types of air pump. However, if a vacuum of 28.5 in. or higher is desired, the steam consumption of the ejector is greater than that required by a hydraulic air pump, provided the air pump is driven by a steam turbine of moderate speed or by a motor.

Losses that occur in surface condensers, that seriously affect the economy of the plant and should be given consideration before the installation is made, are as follows: (1) Drop in vacuum, or difference in pressure between the inlet and the air-pump connection; (2) difference in temperature of the entering steam and condensate; (3) incomplete air removal.

The first loss is dependent upon the size and the shape of the shell, provided the tube spacing is correctly designed; that is, using differential spacing, decreasing the space between the tubes from the top to the bottom of the shell and assuming that the condenser is of conventional design and not provided with steam lanes down through the nest of tubes to eliminate the drop through the condenser.

The second loss can be reduced to a minimum by careful design. Several large condensers have been built with rain plates inserted to give a substantially dry-tube condenser. However, the resultant loss due to the steam having to travel at right angles causes a loss equal to if not greater than the effect of producing cold condensate. The condensate temperature can be raised by the use of a primary heater in the top pass, but this construction is expensive both as to the cost of the condenser and the additional piping required. In the conventional design of condenser of large size, the condensate rains down through an appreciable space and in coming in contact with the cold tubes, its temperature is reduced 5 to 10 deg. below that of the incoming steam. Obviously additional heat is required if the condensate is to be used for boiler-feed purpose.

*Abstract of paper read before joint meeting of Western Society of Engineers and the Chicago Sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers.

It is extremely important that the tubes be properly spaced. If they are packed tightly together to obtain as much surface as possible in a given size of shell, there is not much room for steam flow. This means that the drop in vacuum will be considerable between the air-pump connection and the steam entrance to the condenser.

Incomplete air removal is caused mainly by air leakage due to the system not being tight and also to the air pump having insufficient capacity. With an inefficient pump air will collect in the lower portion of the condenser, the direct effect being to lower the temperature and to reduce the heat head between the water in the tubes and the steam space. Consequently the heat transfer will be reduced and the condenser less efficient.

Either the hydraulic air pump or the steam ejector is capable of reducing the air tension or pressure in the condenser to practically zero, so that the maximum temperature is maintained in the steam space nearest the offtake, meaning that the heat transfer will be increased. The maintenance of high temperatures in the lower part of the condenser also insures the condensate being at the maximum temperature, as it will assume the temperature of the vapor. It must be borne in mind that for every 10 deg. increase in the temperature of the condensate fed to the boilers approximately 1 per cent. of fuel is saved.

With a reciprocating pump the temperature in the steam space in the bottom part of the condenser is about 15 deg. less than in the top part, due to inefficient air removal. With the hydraulic air pump or steam ejector the temperature in the steam space is nearly the temperature of the steam at the entrance of the condenser, so that the temperature of the condensate is nearly that of the entering steam.

In a jet condenser the only effect of air being present is to have its pressure added to the vapor pressure, reducing

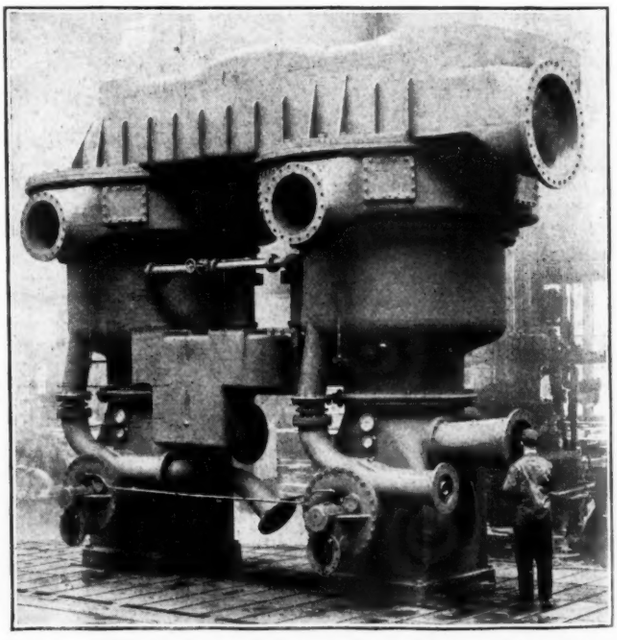


FIG. 2. TWIN JET CONDENSER CAPABLE OF HANDLING 18,000,000 LB. OF WATER PER HOUR

the vacuum by a corresponding amount. That is, if in a condenser carrying, say, 28 in. of vacuum, air was allowed to collect in such amounts that its pressure was ½ in., then the vacuum would be reduced to 27.5 inches. In a surface condenser, however, the collection of air to the extent of its exerting a pressure of ½ in. would make the

vacuum much worse, as the effect would be relatively threefold. It would tend to diminish the vacuum to the same extent as in a jet condenser. The air present would insulate or blanket the tubes so that the heat transfer from the steam space to the water space would be seriously interfered with. The presence of air would also lower the temperature in certain zones of the steam space in the condenser, so that there would be less "heat head" to create a transfer of heat.

From the foregoing it will be seen that to get the best results from a surface condenser it is necessary to have air-removal apparatus that can practically maintain the air pressure in the shell at a negligible value.

In theory an ideal condenser should resemble a cone in shape, so that the velocity of the entering steam would be maintained constant to the point of air offtake. Such a condenser would not be practical to build, and the space required would be prohibitive.

In the condenser shown at the right of Fig. 1, the feature of constant steam velocity is obtained. Steam enters the tube nest substantially around the entire periphery of the shell and the area of the steam space decreases as condensation takes place. The drop in vacuum from the top of the condenser to the air offtake is negligible, because the path of the steam is so short.

The condensate temperature is in all cases equal to the incoming steam temperature, and test results denote that it is even 2 to 5 deg. higher. The reason for this is that the area of the steam space at the bottom is slightly contracted, so that there will be an increase in velocity and obviously an increase in pressure, due to compression. This will cause an increase in temperature and the raining of the condensate through this steam would mean that the condensate would assume the increased temperature. The air is taken off at the center of the shell, the coldest part of the condenser.

With regard to heat transfer, the statement has been made that certain manufacturers are more conservative than others. This is no doubt due to the type of air-removal apparatus used in conjunction with the condenser. With efficient air-removing apparatus it is possible to establish artificially a greater heat head within the condenser, or in

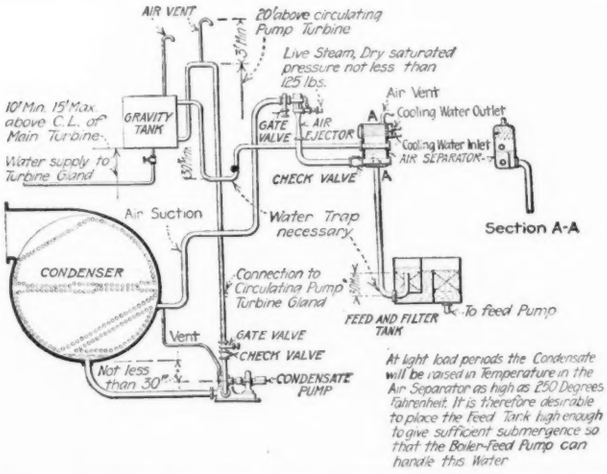

AIR VENT
20' above circulating Pump Turbine
3' Min.
Live Steam, Dry saturated pressure not less than 125 lbs.
10' Min. 15' Max. above C.L. of Main Turbine
GRAVITY TANK
GATE VALVE
AIR EJECTOR
Air Vent
Cooling Water Outlet
Cooling Water Inlet
AIR SEPARATOR
Water supply to Turbine Gland
CHECK VALVE
Air Suction
Water Trap necessary
Section A-A
CONDENSER
Connection to Circulating Pump Turbine Gland
To feed Pump
FEED AND FILTER TANK
Vent
GATE VALVE
CHECK VALVE
Not less than 30"
CONDENSATE PUMP
At light load periods the Condensate will be raised in Temperature in the Air Separator as high as 250 Degrees Fahrenheit. It is therefore desirable to place the Feed Tank high enough to give sufficient submergence so that the Boiler-Feed Pump can handle this Water

FIG. 3. DIAGRAMMATIC ARRANGEMENT OF AIR EJECTOR SYSTEM FOR MARINE CONDENSER

other words it is possible with the efficient apparatus to use a smaller condenser to do substantially the same work as a larger condenser with inefficient air removal.

The unit type surface condenser is designed for power plants of relatively small capacity and is built up to sizes having 6000 sq.ft. of surface. The auxiliary equipment of pumps occupies little additional space as they set directly under the condenser. The air pump receives its water supply from the main circulating system, regulation by a hand-operated valve giving the proper working suction for the pump. The shell and pumps are supported on beams or concrete, the foot farthest away from the pump being left free to move in the horizontal plane to allow for expansion due to temperature changes.

In low-level jet condensers the progress made in the past few years has been remarkable. Improvements in design with specific reference to spray nozzles and removal of air have decreased the terminal temperature difference between steam and discharge water from 10 to 5 deg., assuming a 28-in. vacuum and 70-deg. water. It formerly was common practice to eliminate the use of jet condensers if the turbine unit was of appreciable size, say 20,000 kw. and up, but there are good reasons why in particular cases a jet condenser should be used. In the past three years jet condensers have been furnished for use in connection with 15,000- to 45,000-kw. turbines and they are operating successfully. The largest jet-condenser installation to date is that installed in the power plant of the Narragansett Electric Lighting Co., Providence, R. I. It is a twin jet condenser such as is shown in Fig. 2, circulating 18,000,000 lb. of water per hour and serving a 45,000-kw. cross-compound turbine. It consists of two single jet condensers interconnected by a steam equalizer at the top with the usual atmospheric relief connection at the end. There is also an air-equalizing connection to equalize the air pressure in the condenser and effectively remove the air in case either pump for some reason or other should be operating at reduced capacity. A water-equalizing connection is also provided to insure each removal pump handling its share of water and also to maintain the same submergence over each pump.

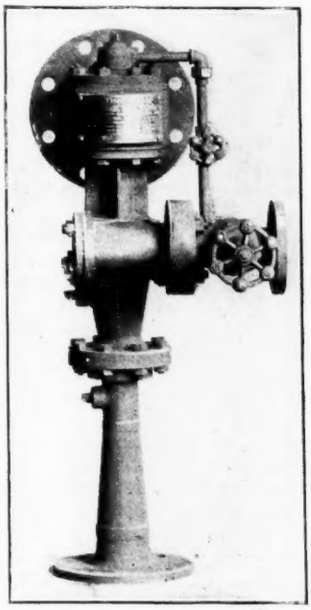


FIG. 4. STEAM AIR EJECTOR

Due to the condensers being equalized in every respect the unit is flexible. If for any reason the one pump is out of operation the condensers can be operated as single units. This arrangement also provides for economical operation; for example, in the winter time with cold water it is only necessary to operate one side of the condenser. If either of the pumps is in need of repairs one set of pumps can be removed bodily and a blank flange inserted. The one pump will then handle the load at a slight decrease in vacuum.

Due to interest in our rapidly increasing merchant marine a few details were given regarding the condensing equipment for the ships. The ships being fabricated by the Merchants Shipbuilding Co. are of 9000 tons dead-weight capacity and are equipped with turbines of 3000 shaft horsepower served by a 4000-sq.ft. main condenser and an 800-sq.ft. auxiliary condenser.

The main condenser auxiliaries consist of a centrifugal circulating pump that can be operated at reduced capacity if requirements demand. Two centrifugal-type condensate pumps serve each main condenser, either pump being capable of handling the maximum condensate. The air-removal apparatus for the main condenser consists of a steam air ejector, Fig. 4, to each main condenser, each of which has sufficient capacity to handle the air, provided the leakage is normal. An air separator is used to condense the steam discharged from the air ejector.

Fig. 3 is a diagrammatic arrangement of the condensing equipment. The condensate pump discharges into the gravity tank, the gravity tank supplying water to the main turbine glands. The overflow from the gravity tank is carried over to the air separator, which consists of a small surface condenser at the top and a crude jet condenser at

the bottom. The ejector discharges into the air separator and the steam from the ejector is condensed in the jet-condenser portion of the air separator. The surface portion of the separator condenses any remaining steam or vapor not taken care of by the jet condenser. There is an air vent at the top of the separator where a slight vapor is given off. The condensate then falls by gravity to the feed tank. To cool the water in the feed tank when the ship is "standing by," a connection is made to the top of the condenser. There is a water connection from the feed tank to the condensate pump so that when there is insufficient condensate from the condenser the pump may be supplied with water. As an air-removal apparatus the steam ejector is efficient due to the fact that the remaining heat in the steam from the ejector is used to heat the feed water. The principal reasons that it is used for marine work are that the weight is appreciably less than that of an air pump, and it has no moving parts.

For land installation the field for steam ejectors for air evacuation is large. The simplicity of the ejector compared with the high-vacuum air pump is a feature. As the ejector has no moving parts and the only replacements necessary consist of steam strainers and nozzles, it will require less attention. If a 28-in. vacuum or less is desired the steam consumption of the ejector is slightly less than that of the hydraulic air pump. However, if 28.5 or 29 in. of vacuum is desired, the capacity of the air ejector must necessarily be greater, and the steam consumption is nearly doubled, while the same hydraulic air pump can be used with the same steam consumption as for 28 in. of vacuum. From the standpoint of steam consumption only, the dividing line is 28 in. of vacuum.

Discussion of the Paper

In the discussion it was stated that the Government would confer a favor on the manufacturer of surface condensers, if, due to the shortage of copper, it enforced the use of steel tubes, tin-coated to eliminate pitting. By the use of steel, trouble from expansion would be reduced. The longevity of steel tubes was questioned and the percentage of nickel to make them durable. Other questions were the proper location and the size of zinc plates used to obviate the effect of electrolysis, the relative longevity of steel and Muntz-metal tubes and the possibilities of tin coating.

In the opinion of Mr. Morgan steel tubes would last as long as bronze tubes if proper precautions were taken to eliminate the action of the water. This was a question for the chemist to solve. Tin coating of steel tubes would be more beneficial than similar coating for Muntz-metal tubes. The difficulty was to obtain an even coating. Little spaces of the original metal would be left open to attack. His experience had been that the life of coated tubes was not appreciably longer than that of uncoated tubes. About 5½ per cent. of nickel would be required in the steel tubes. In heat transfer through steel tubes the time element would be an important factor, so that cooling-water velocities should be relatively low. With a steel tube perfectly clean the heat transfer might be 85 per cent. of that obtained with Muntz metal, but in actual operation with the tubes coated the heat transfer would probably drop to a figure ranging from 40 to 60 per cent. If steel tubes are used it is obvious that it will be necessary to eliminate brass tube plates and circulating-pump impellers, using steel or cast iron instead.

Admiralty-metal tubes with zinc plates were better than copper tubes. The proper location for the zinc was on the inner surface of the handhole covers and the proper ratio was 1 sq.ft. of zinc plate per 1000 sq.ft. of condensing surface.

Rather than go into the high costs involved in high pressures, it was Mr. Morgan's suggestion that efforts should be made to first use to full advantage the vacuums that are now available from the modern condenser. Designers need fuller information than they get from the average plant. Average yearly conditions are seldom taken and it is a usual thing to put in a condenser too small for the maximum work expected of it.

Another important item instigated by the thought of fuel conservation is that the manufacturers of condensers are not consulted to a sufficient degree when condensing apparatus gives trouble. Countless opportunities are given to correct defects and increase vacuum, but the worst of the situation is that when letters arrive, the complete information regarding the trouble, which the operating engineer could give, is lacking in a marked degree. Periodical inspection would be of great benefit, especially at this particular time when every concern in the country is taxed to full capacity. If repair parts could be anticipated in advance of needs a great deal of coal would be conserved.

Railroad Electrification and Water Supply

Mr. McAdoo's plan to electrify most of the United States railroad mileage, which is regarded by railroaders as feasible only in certain districts, calls attention anew to the great water-power resources of North America, says the *Boston News Bureau*. Canada's water-power is incalculable, much of it being in unsettled areas, but all over the Dominion available water-power is found in abundance where most needed or most likely to be needed. In the United States the maximum potential water-power is estimated at 60,713,200 hp., of which only 5,321,699, or 8.8 per cent., has been developed. The far West, especially the Pacific states, is very much in the lead in maximum potential water horsepower, the State of Washington being first on the list, with 9,990,000, followed by California with 8,865,000 and Oregon with 7,505,000. The percentages of development in those three states are 3.2, 8.2 and 2.1 respectively. Montana ranks fourth with 4,290,000, of which only 4.1 per cent. has been developed. Then comes the State of New York, with 4,242,000, of which 18.8 per cent. has been developed.

Other states exceeding the million mark are as follows: Idaho, 2,910,000; Arizona, 1,930,000; Colorado, 1,928,000; Utah, 1,490,000; Wyoming, 1,470,000; Alabama, 1,070,000. North Carolina has an even 1,000,000, and Maine falls below million mark by 84,000, but is 15,000 ahead of combined total for New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

Montana's water power is peculiarly adaptable to transportation purposes, and it was the St. Paul's successful electrification of 440 miles of its mountain divisions, with proposed extension of electrified system to the Pacific coast, and a similar project by the Great Northern which impressed the director general of railroads with the possible utilization of the country's latent water power for general electrification of all systems, more or less. Railroad operators say the water power is not distributed throughout the country in proportions suitable to complete electrification and that in many sections where it is the cost would be prohibitive. Oil burning locomotives of the Southern Pacific and Santa Fe, for illustration, they say, are more economical and, under the circumstances, more effective.

However that may be, there is running to waste 16,000,000 water horsepower in excess of the entire steam-engine horsepower, including locomotives.

Water-power development has been retarded by restrictive laws. An engineering report submitted to the Chamber of Commerce of the United States says: "Of the 55,000,000 undeveloped water horsepower in the entire country, approximately 40,000,000 is located within the boundaries of the so-called Western water-power states, where the Government still retains as proprietor 760,000,000 acres, or more than two-thirds of the aggregate acreage of those states combined. To develop power in that section it is therefore nearly always necessary to use some part of the public domain, if not for the dam site itself, at least for flowage, for transmission right-of-way, or for some other purpose. The existing laws forbid such use except under permit by the Secretary of the Interior, revocable without cause at any time by himself or by his successor in office."

How far and how long ammonia can be spared for refrigeration cannot now be said. Plants most extravagant in its use will naturally be closed first. The efficient plants are in the best position so far as this question is concerned.

Boiler-Room Efficiency*

By A. H. BLACKBURN
Chief Engineer, Underfeed Stoker Company of America

Boiler-room efficiency bears directly on the smokeless combustion of fuel. The smoke inspector today may be said to have finished his work when he has succeeded in getting users to abolish the discharge of volumes of black smoke from the stacks; but if the user, in accomplishing this result, does not at the same time increase his boiler-room efficiency, the inspector, sooner or later, will have to do his work again. Consuming smoke does not necessarily mean increased economy.

Analysis of Fuel

As the largest item of expense is fuel, the first consideration should be given to the careful buying of such coal as will give the best results commercially. Coal giving the highest boiler-room efficiency may not commercially be the most economical—the volatile grade of coal selling at a lower price giving from 68 to 70 per cent. efficiency may work out better than a higher priced coal giving 75 per cent. efficiency. Coal, therefore, should be purchased on price and a guaranteed analysis, with clause covering reduction or advance in price accordingly to the quality actually supplied. The Bureau of Mines, Washington, has drawn up complete specifications to be used in Government departments, copy of which can readily be secured.

Whether coal is bought on analysis or not, a sample should be frequently taken and analyzed to check up the efficiency being obtained. For this purpose an approximate analysis will be sufficient, giving moisture, volatile combustible, fixed carbon and ash. Enough consideration is not given in the buying of coal to the matter of the ash and its fusing points for the successful working of the type of grate or stoker installed. Tests made on the Jones underfeed stoker show that some ash will fuse at a temperature of over 2500 deg. F. and is classed as non-clinkering, and other ash under 2500 deg. F., which is stipulated as clinkering.

Avoid ash that contains silicate less than 30 per cent., alumina less than 30 per cent., iron oxide above 15 per cent., lime above 10 per cent., magnesia above 3 per cent.; but, as is generally known, coals with a low ash are the most efficient, from both a practical and a theoretical point of view. More ash means more labor in handling the fires and carrying away the ashes; a greater air pressure is required and there is greater loss through infiltration of cold air through the boiler settings.

Procuring a sample of coal for analysis is as important as the analysis itself, because a nonrepresentative sample will not produce correct deductions. The Bureau of Mines requests that 1000 lb. for a sample be taken in all cases, but for small plants getting coal in carloads or by the wagonload, representative shovelfuls taken from different parts of the car or wagon pile on the ground to the extent of 350 lb. will suffice. This should then be crushed either through a crusher or with an iron tamper and mixed thoroughly; following, divide the sample into four quarters, and take one quarter and mix it up again, and then divide into four parts. Take the last part and put it into an air-tight jar and seal up ready for the chemist.

Losses in the Boiler Room

Look out for the small losses, otherwise these will amount to a large item in a year's time. Consider the following:

1. Examine the brickwork of the boiler setting carefully for cracks which will allow infiltration of air into the combustion chamber, and for air spaces around the structural steel supporting the boiler. The cracks and openings through examination can be detected with a candle—if there are openings the flame will be drawn in. Another way is when green coal has just been put on to shut the chimney damper for a moment and the smoke will come out of the cracks.
2. See that all fire, ash and inspection doors close tight.
3. See that all steam pipes are insulated properly with 85 per cent. magnesia covering or its equivalent.
4. Examine the boiler feed pumps and auxiliaries to see that they are not wasting or blowing the steam past the piston rings.
5. Have the boiler blowoff valve pipe outlet exposed to view so that any leaks may be detected.
6. Stop leaks at joints in the steam-pipe connections immediately.
7. Have a smooth boiler-room floor and see that all of the loose coal is swept up, otherwise it gets mixed with the ash and is lost.

Boiler-Room Instruments

Every boiler-room should be equipped with: (1) Three draft gages or one draft gage with three connections to test the pressure in the air chamber under the stokers or grates, over the fire and outlet to the breeching or stack. (By this means air holes in the fire can be detected to find out whether too much or too little draft is being used to get the best results); (2) recording steam-pressure gage; (3) water meter; (4) CO_2 recording machine; (5) high-temperature thermometer, reading to 1000 deg.; (6) coal scales, recording or otherwise; (7) feed-water regulators.

With these different instruments results can be checked up at any time, and poor conditions immediately detected. No plant can be efficient without the full consideration for the human element, and the well-equipped boiler house with instruments as noted is a great factor in getting results from firemen. The fireman takes pride in his work and aims for results with proper encouragement from the chief engineer. A boiler-room well ventilated in summer and warm in winter adds to the general efficiency.

Methods of Coal Handling

In the modern boiler plant coal is handled mechanically direct into the stoker hoppers, but in many small boiler rooms this is not always possible, and in such cases the coal is handled by manual labor. Considering this latter condition, many boiler houses can be found where the fireman makes two moves where one would do, and where by a careful study of the situation, a little ingenuity displayed and a motion study made, a correction would reduce the actual work of the fireman one-half.

The principal efficiency obtained in any boiler room is naturally the way in which the fires are handled to suit the coal, established as the most commercially economical to use or that which the particular location compels. With high labor cost and insufficient supply, hand-firing is becoming obsolete and rightly so, excepting in the case of a single boiler plant under certain conditions. There are two ways of hand-firing, the spreading method and the coking method. It is the writer's experience that the spreading method gives the better efficiency in the long run; the coking method, however, if carried out carefully, gives the least smoke, but the difficulty is getting the work done right; for this reason alone, the spreading method is more efficient.

The spreading method consists of opening the doors alternately, spreading the fuel from the front to the back wall evenly over the surface of the fire; this means that one side of the fire is always bright and the other covered with green coal. The coking method consists of placing considerable coal on the front quarter of the grate and on the dead plates, and after it cokes, pushing it back gradually and filling up the front again.

The most efficient practice, however, is to install stokers which may be divided into three general types—overfeed, underfeed and chain-grate.

The principle of the underfeed stoker is that there is always a hot fire on the top and the green coal is fed underneath; the volatile gases are given off and, passing through an incandescent bed of fuel, are consumed thoroughly, making the boiler smokeless except when the fires are first started or being cleaned.

With the underfeed stoker, the full benefit of the heat radiated from the surface of the fire is obtained, as is also

*Paper presented at the meeting of the Smoke Prevention Association, Newark, N. J., August, 1918.

the heat carried to the boiler surface by the hot gases of combustion; and the heat radiated from the bottom of the fire is heating the coal up and distilling the gases. On the other hand, with an overfeed stoker, the covering of green coal for some time prevents the heat of radiation from reaching the top of the fire, and the radiation from the bottom of the fire is lost.

A closed air chamber is used and air forced through the tuyeres into the retorts; the steam pressure controls the whole operation, the same being automatic. If the steam goes up the blower slows down, reducing the volume and pressure of air going through the tuyeres, at the same time cutting down the supply of coal to the retort, making an ideal condition. The underfeed stoker will take care of loads varying from no load to 200 per cent. within periods of three to four minutes, and do it efficiently.

All stokers, however, demand some intelligence to operate; different kinds of coal require different methods of handling and no fixed rule for firing, air pressure, etc., can be set down for any particular coal. Coals that by an approximate analysis may appear the same, may have to be handled quite differently to get the best results caused by the different composition of the ash.

As a general rule the low-volatile, high-carbon coking coals of the East require a fairly heavy fire and high blast pressure to cut the coke. The high-volatile coals of the Middle West require a lighter fire and a volume of air at less pressure. The lignite coals of the West are burned most successfully on an underfeed stoker by running a very light fire at a rapid rate with a large volume of air at a low pressure and burning them before drying out.

High CO_2 and the absence of CO result in high initial furnace temperature and high furnace temperature means greater efficiency. Don't run five boilers at a low furnace temperature and low efficiency when the same work can be done with four boilers at high furnace temperature and greater efficiency. With a CO_2 recording machine, the man in charge can check up the efficiency as he goes along. If the CO_2 is averaging less than 10 per cent. he should investigate the boilers individually, study the draft gages, taking the temperature of the escaping gases and examining the fires to see that there are no holes in them.

Every boiler room of large capacity should have a competent and technically trained engineer in charge with full authority, whose only duty in the boiler plant should be to get results. In the smaller boiler plant the chief engineer who is usually responsible should realize that the efficiency of the plant as a whole depends to a very large extent on the operation of the boiler room.

Having found by careful tests which is the best way to burn the coal to the best efficiency, see that the firemen carry out instructions. Keep a record of the results each fireman obtains and where possible pay him a bonus on his individual efforts, and not on the results as a whole.

In conclusion, the value of the use of instruments, the buying of coal by analysis and the other items referred to in the foregoing is very largely lost if careful records are not kept of the daily results and comparisons made weekly and monthly. Forms should be made out on which should be recorded daily the amount of coal used, water evaporated, temperature of feed water, pressure of steam, CO_2 record and draft pressures, analysis of the coal and the amount of ash wheeled out. From the daily reports, weekly and monthly summaries should be entered on forms and turned into the main office.

Government Restricts Sale of Surface Condensers

Following a conference of the brass manufacturers with B. M. Baruch, chairman of the War Industries Board, and other members and officials of the Board and representatives of the Navy and the Emergency Fleet Corporation, and a later conference of the Board with the War Service Committee of the surface type condenser industry, it was decided, in order to conserve brass, to regulate distribution of these condensers which are essential to ships.

There are about 45 manufacturers affected by the decision of the War Industries Board. They are being notified to take no further orders and enter into no new contracts for sale or to sell or deliver to any purchaser, government or civilian, except on a permit issued by the War Industries Board. To get such a permit the proposed purchaser must show his need to the satisfaction of the Board, and this need will be considered in connection with the needs of the Government in the conduct of the war.

The manufacturers will be permitted to fill, where possible, existing orders with nonferrous condenser tubes on contracts for shipment prior to Jan. 1, 1919. On contracts after Jan. 1, 1919, the manufacturers are urged to put steel tubes on condensers for land uses and are directed to send immediately estimates for steel required for this purpose. The Navy and the Emergency Fleet Corporation are exempt from these orders and regulations of the War Industries Board as to condensers for ship usage, but not as to condensers for land stations.

Some months ago the Government took over control of and distribution of the turbine-engine industry, because of the shortage in the supply and their essential need in the Navy and Emergency Fleet war program. The nonferrous condenser is an essential integral part of the turbine, and shortage in its production caused the Navy and Emergency Fleet Corporation officials to appeal for Government regulation of production and distribution.

The effect of the taking over by the Government of the surface-type condenser-tube industry was considered carefully by the brass manufacturers with Mr. Baruch, Everett Morss, chief of the nonferrous tubing section, and Walter Robbins, chief of the Electrical and Power Equipment Section. It is the purpose of the Government to stimulate production to meet war needs first and supply civilian needs if possible.

Government Needs Stenographers and Typists

The Civil Service Commission is having difficulty in meeting the great demand for stenographers and typewriters in the Government offices in Washington. Women, as well as men, are needed. Those who have not the required training are encouraged to undergo instruction at once. Tests are given in 550 cities every Tuesday. The Government maintains a list of available rooms in private houses in Washington and is erecting residence halls to accommodate thousands.

Full information and application blanks may be obtained from the secretary of the local board of Civil Service Examiners at the post office or custom house in any important city.

Providing Homes for Returned Soldiers

Secretary Lane presented to the President and to Congress recently a comprehensive plan for a preliminary study of the unused lands of the country, with particular reference to the irrigation of some 15,000,000 acres of arid land, the drainage of between 70,000,000 and 80,000,000 acres of swamp land and the clearing of approximately 200,000,000 acres of cut-over or logged-off land, with the purpose in view of reclaiming these lands through Governmental agency and providing homes for returned soldiers.

The Secretary's letter is receiving the enthusiastic support of Senators, Congressmen and leading newspapers.

The Secretary is asking Congress for an appropriation of $1,000,000 to be used in the work.

Chairman Hurley of United States Shipping Board says that during the past year 277 seagoing vessels totaling 1,710,121 deadweight tons, were completed, and only four of these have been sunk. The shipbuilding program of United States calls for 15,000,000 tons—enough to sustain 5,000,000 men in France. Seagoing shipping has expanded to nearly 8,000,000 tons, and our output exceeds that of any other nation with the prospect that it will be at the rate of 500,000 tons a month by the end of the year.

New Publications

DIFFUSION OF OXYGEN THROUGH STORED COAL

Technical Paper No. 170, of the Bureau of Mines, deals with "The Diffusion of Oxygen Through Stored Coal" and is written by S. H. Katz. The experiments described were made to determine the effects of the size of coal and the proportion of air spaces on the rate at which oxygen can be brought by diffusion from the air around the pile to the coal within, the purpose being to discover the bearing of diffusion on spontaneous heating of the coal. The results of the investigations are summed up as follows:

1. The principles stated in Fick's law of diffusion have been found applicable to the diffusion of oxygen through the atmosphere of the voids of broken coal.

2. In a mass of broken coal, through which oxygen is diffusing, the size of the pieces has within practicable limits no effect on the rate of diffusion, all other conditions being constant.

3. If the proportion of voids in a mass of coal pieces is varied, the time required for a definite diffusion of oxygen increases approximately in inverse proportion to the percentage of voids. The product of the percentage of voids and the time required for a given diffusion increases directly with the increase of the percentage of voids.

4. The amount of oxygen diffusing through the interstices in a mass of coal pieces seems to vary inversely as the depth of the coal. Enough experiments to justify a more definite conclusion have not been made.

5. Coal stored in lumps or smaller pieces of uniform size contains a high proportion of voids and oxygen diffuses readily through the mass. In run-of-mine or slack coal, which contains a great variety of sizes, the proportion of voids is less and the diffusion of oxygen is slower.

6. Mixing different-sized pieces in a mass tends to reduce the proportion of voids. In storing coal in the air factors other than diffusion may be accelerated or retarded by changes in voids; but if diffusion alone be considered, mixing the sizes of coal will reduce the oxygen entering the pile by diffusion.

7. Building of a coal pile, so as to reduce or prevent segregation of the large and the small pieces, will lessen the proportion of voids in the pile, will tend to keep down the amount of oxygen entering the pile by diffusion, and thus reduce oxidation from this source.

Engineering Affairs

The New York Section of the American Society of Refrigerating Engineers will hold its fourth informal dinner of the year on the evening of Sept. 18 at the Machinery Club, 50 Church St. After the dinner C. R. Neeson will read a paper on the operation of electrically driven ice plants.

The Chicago Chapter of the American Association of Engineers gave a dinner at the City Club on the evening of Sept. 4, to welcome its incoming secretary, C. E. Drayer, who made a brief address. Joseph Harrington, fuel administrative engineer for the State of Illinois and Dr. H. W. Nichols, secretary of the Chicago Section of the A. S. M. E., also spoke.

The Fourth National Exposition of Chemical Industries will be held in Grand Central Palace, New York City, Sept. 23-30. An elaborate and important program has been arranged for the week and each evening there will be shown films on interesting subjects, including Water Power, Its Development and Use; Niagara Falls; Power Transmission; Power of Wealth—Hydraulic Development; Canadian Shawinigan Falls Power Development and Its Surrounding Chemical Industries, etc.

The American Association of Engineers, through its president, W. H. Finley, announces the appointment of a committee of prominent engineers to study after-the-war conditions. It consists of Isham Randolph, chairman; Edmund T. Perkins, Gardner S. Williams, and Samuel Moreell, secretary. The committee will be increased as it gets into the work and will join forces with other agencies in Chicago and throughout the country that are now studying the problem. The questions for early consideration are largely those of human engineering. Behind these are certain broad principles upon which as a foundation plans for reconstruction and for the better employing of natural resources and man power are based.

The Seventh Annual Safety Congress of the National Safety Council will be held at the Hotel Statler, St. Louis, Mo., Sept. 16-20. An elaborate program of events has been prepared. A message emphasizing the pressing need for the conservation of man power will be received from President Wilson. A member of the Cabinet will deliver the principal address at a public meeting to be held on the opening day of the convention—"Safety as an Asset in Winning the War," by the Hon. Franklin K. Lane, will express the views of our National Government in its determination to prevent every avoidable accident in industrial America. Charles M. Schwab, Director of the Emergency Fleet Corporation, will give the principal address at the opening session of the convention, his subject being "The Democratization of Industry."

Miscellaneous News

Under the Auspices of the Conservation Committee of the United States Fuel Administration of Westchester County, N. Y., an illustrated lecture on "Economic Firing of Boilers" will be delivered at 2 o'clock in the afternoon of Sept. 18, by Charles H. Bromley, associate editor of *Power* in the court room of Part 1 of the Supreme Court of Westchester County, court house, White Plains, N. Y.

Coal Comes First, under an order of the War Industries Board covering the distribution of power by the West Penn Power Co. in the Pittsburgh district. The order will give coal mines a full supply of power, although other war industries served by the West Penn Company are now working a restricted number of hours. The vital importance of maintaining the increased production of coal, and the necessities of industries served by the mines in the Pittsburgh district, presented to the War Industries Board by the Fuel Administration, prompted the order giving the mines first call on the available power.

Business Items

The Jeffrey Manufacturing Co. announces the reopening of its Cleveland branch office, at 437 Leader-News Building, which will be in charge of Messrs. P. C. Dierdorff and C. B. Reed.

The G. M. Davis Regulator Co., Chicago, announces that two big exhaust relief valves, weighing 12,300 lb. each, have been shipped to the American Gas and Electric Co., at Beech Bottom, W. Va. This is a repeat order, as two similar valves were previously supplied to the same company.

The Buffalo Forge Co. has received an order for stoker fans to be installed in the Old Hickory smokeless-powder plant, the largest of its kind in the United States, built by the Dupont Engineering Corporation for the United States Government. The fans will each handle 10,000 cu.ft. of air per minute and furnish draft to sixty-eight 820-hp. boilers.

The Quigley Furnace Specialties Co., New York, has secured a contract for a powdered coal plant from the Whitaker Glessner Co., Beech Bottom Works, West Virginia, to furnish four tons of powdered coal fuel per hour to supply 20 furnaces for heating 6-in. shell forgings. This equipment is arranged for large extensions for future applications in other departments in the mills, including boilers.

Trade Catalogs

The R. H. Beaumont Co., Philadelphia, Penn., announces the publication of its Catalog 38, describing and illustrating the "Beaumont Drag Scraper System for the Ground Storage of Coal."

New Construction

Proposed Work

Mass., Boston—The Bureau of Supplies and Accounts, Navy Dept., Wash., D. C., will install motor generators, Schedule No. 5854½.

R. I., Middletown—The Newport, Fall River and Providence Hotel Association, will install a vacuum system in the proposed 6-story, 300 room hotel at Easton's Beach. Total estimated cost, $700,000.

Conn., Bridgeport—The United States Housing Corporation, 886 Main St., has awarded the contract for the construction of a 2½-story community house on Grasmere St., to the Cauldwell Wingate Co., 381 Fourth Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $220,000.

Conn., Middleton—Middlesex County Hospital, 28 Crescent St., plans to install heating and electric systems in connection with the proposed 3 story, 40 x 100 ft. hospital. Total estimated cost, $75,000.

Conn., New Haven—The Eastern Machine Screw Co., Truman Ave., has awarded the contract for the erection of a 1-story, 80 x 55 and 81 x 55 ft. factory, to C. W. Murdock, 185 Church St. Equipment to include motors, belting and shafting will be installed in same. Total estimated cost, $15,000.

N. J., Bloomfield—The General Electric Co., River Rd., Schenectady, N. Y., is having plans prepared by C. G. Hulth, Engr., Schenectady, N. Y., for a 1-story, 90 x 190 ft. power house on Watsessing Ave. Equipment including boilers will be installed in same. Total estimated cost, $100,000.

Penn., Philadelphia—The Bureau of Supplies and Accounts, Navy Dept., Wash., D. Co., will install gasoline generators. Schedule No. 5882½.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., will receive bids for furnishing equipment, as follows:

Sept. 20—Schedule 5801½, two steam towing machines, delivery Boston, Mass.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., will receive bids for equipment as follows:

Sept. 19—One motor generating set, Schedule No. 5763½, delivery San Diego, Calif.

Sept. 27—Four steam turbine-driven blowers, 6 evaporators, 6 distillers and feed water heaters. Schedule No. 5769½.

Va., Claremont—The Claremont Marl Products Co., 424 Dickson Bldg., Norfolk, will install electric generators, pumps and engines, in connection with its 408 acre marl development. R. K. Mead Co., Law Bldg., Baltimore, Md., Engr.

Va., Norfolk—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install an air compressor at the Navy Yard here.

Va., Portsmouth—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a turbo generator in the Navy Yard here.

W. Va., Buffalo—The Putnam Dairy Co., Charleston, will install a steam heating system in the proposed 1-story, 100 x 101 ft. dairy plant. The company is in the market for refrigerating machinery. Total estimated cost, $60,000. C. D. Cooley Co., Century Bldg., Pittsburg, Pa., Engr.

W. Va., Charleston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install an air compressor at the Navy Yard here.

W. Va., South Charleston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a turbo generator in the Navy Yard here.

S. C., Charleston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a turbo generator in the Navy Yard here.

La., New Orleans—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a turbo generator in the Navy Yard here.

La., New Orleans—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install an air compressor at the Navy Yard here.

Ohio, Bloomdale—Village voted $15,000 bonds to build an electric lighting plant.

Ohio, Cleveland—The Board of Education is receiving bids for the installation of a steam heating system in the proposed 1-story, 10 room school. Total estimated cost, $150,000. W. H. McCornak, Arch.

Ohio, Cleveland—H. M. Morse Co., Engr., 413 Citizens Bldg., is receiving bids for the installation of a steam heating system in the proposed 1-story, 60 x 128 ft. factory for the L. & N. Co. Total estimated cost, $50,000.

Ohio, Cleveland—The Van Dorn and Dutton Co., 2978 Woodhill Road, plans to build a 1- and 2-story, 60 x 178 ft. factory. A steam heating system will be installed in same. Total estimated cost, $40,000.

Ohio, Dayton—The Brownell Co., North Findlay St., is in the market for a 5 ton, three motor electric traveling crane.

Ohio, Ivorydale—The Proctor and Gamble Co., Spring Grove Ave., will build a brick boiler plant here. Estimated cost, $45,000.

Ohio, Lima—The Lima Locomotive Works, South Main St., is having plans prepared by W. McConkey, Engr., for extensions to its factory. Complete power equipment will be installed in same.

Ohio, Middletown—The Paul Sorg Paper Co. has awarded the contract for the erection of a 2-story, 25 x 288 ft. paper mill to Caldwell & Iseninger, 5th St. A steam heating system will be installed in same. Total estimated cost, $60,000.

Ohio, Orrville—The Ohio Blower Co. ,Detroit and West 93rd St., Cleveland, will install a steam heating system in the proposed 2-story factory. Total estimated cost, $100,000.

Ohio, Warren—The Heltsell Steel Form Co. is receiving bids for the installation of a steam heating system in the proposed 1-story, 45 x 104 ft. steel plate factory. Total estimated cost, $40,000.

Ill., Chicago—The Armour Co., 288 South La Salle St., has awarded the contract for the erection of a 9-story, 210 x 240 ft. cold storage plant on 44th and Packers Ave., to Blome-Sinek, 139 North Clark St. Estimated cost, $1,500,000.

Ill., Chicago—The Board of Education plans to enlarge the existing heating plant in connection with the proposed 3-story, 105 x 160 ft. school addition on Erie and Lamon St. Total estimated cost, $200,000. A. F. Hussander, 5 South Dearborn St., Arch.

Ill., Chicago—A. J. Jordan, 111 West Washington St., will install a low pressure steam heating system in the proposed 6-story, 165 x 350 ft. warehouse on Elston and Montrose St. Total estimated cost, $400,000. J. A. Armstrong, 11 South La Salle St., Arch.

Ill., Sardoris—City voted $65,000 bond issue for the erection of an electric light, heat and power plant.

Wis., Janesville—The General Motors Corporation, 88 East Congress St., Detroit, Mich., has awarded the contract for the construction of a 1-story, 50 x 200 ft. factory, to J. P. Cullen. A steam heating system will be installed in same. Total estimated cost, $180,000.

Iowa, Missouri City—City will soon award the contract for the installation of pumps to deliver the water to the reservoir against 35 ft. head 700 gal. per minute with the pump thence to the distributing reservoir with 235 ft. lift, in connection with the proposed sinking of two 12 in. wells, each 90 ft. deep; or the installation of 3 pumps in the existing wells and pump from the reservoir to the distributing reservoir; or installing a pump direct from the wells to the distributing reservoir, 260 ft. lift, also two 3-phase, 60 cycle, 2200 volt motors. C. L. Huff, Logan, Engr.

Kan., Anthony—The Board of Education is having plans prepared by W. Mampe, Arch., 529 Sheidley Bldg., Kansas City, for the erection of a 3-story, 71 x 128 ft. high school. A steam heating system will be installed in same. Total estimated cost, $50,000.

Kan., Pittsburg—The United Iron Works will install steam heating and steam power systems in the proposed 2-story, 160 x 240 ft. blacksmith shop. Total estimated cost, $18,000.

Kan., Rocky Fork—The Rocky Fork Milling Co., Manhattan, is having plans prepared by J. C. Jacobson, Engr., 1135 First National-Soo Line Bldg. for the erection of a power plant here.

Wyo., Torrington—City plans an election soon to vote on bond issue for purchasing a new engine for the electric light plant.

Okla., Henryetta—City plans an election soon to vote on $100,000 bond issue for building a transmission line from city pump station to north fork Canadian, and for the installation of two pump motor sets with piping, wires, fittings and auxiliaries; duplicate steam boilers and auxiliaries; duplicate electric generator sets, and other machinery for the improvement of the water works system.

Okla., Tulsa—The T-B. Gasoline Co. is in the market for two 50 hp., two 100 hp. and one 75 hp. Miller two cylinder gas engines.

Colo., Ault—City is having preliminary plans prepared by G. H. Sethman, Engr., 249 Equitable Bldg., Denver, for the erection of a new municipal light plant.

Utah., Parowan—City plans to build an electric light plant. F. McGonagle, Engr.

CONTRACTS AWARDED

R. I., Providence—City has awarded the contract for the construction of a new 200,000,000 gal. capacity regulating dam and reservoir, to E. W. Foley Contracting Corp., 34 Pine St., New York City. Estimated cost, $38,545.

N. Y., New York—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the installation of a steam heating system in the structural shop, to Enterprise Steam and Hot Water Heating Co., 600 North Howard St., Baltimore, Md. Estimated cost, $62,906. Noted July 30.

N. J., Pompton Lakes—The Borough Council has awarded the contract for the installation of 2 hydraulic turbines, 2 generators, also switchboard and electrical fixtures in the Pompton Lakes municipal electric plant, to Westinghouse Co., 37 Wall St., New York City, and S. Morgan Co., on their combined bid of $21,300.

D. C., Wash.—Bids were received by the Bureau of Supplies and Accounts, Navy Dept., for furnishing equipment as follows:
Schedule 5505¾, Class 151, one electric motor, one rheostat, one motor totally enclosed, and rheostat, delivery Annapolis, Md., from Allis-Chalmers Co., Clinton St., Milwaukee, Wis., $730; Electro Dynamic Co., Ave. A, Bayonne, N. J., $589; Eck Dynamo and Motor Co., Bayonne, N. J., $592; Fidelity Electric Co., 331 North Arch St., Lancaster, Penn., $548; Ideal Electric Co., 153 East 5th St., Mansfield, Ohio, $766; Industrial Controller Co., 886 Grentrust, Milwaukee, Wis., $30 part bid; Mechanical Appliance Co., 133 Stewart St., Milwaukee, Wis., $545; North Western Manufacturing Co., 480 Clinton St., Milwaukee, Wis., $415; Peerless Electric Co., West Market St., Warren, Ohio, $624; Robbins & Meyers, Lagonda and Farlow St., Springfield, Ohio, $460; Reliance Electric Co., Munsey Bldg., $485 part bid; Standard Electric and Elevator Co., 418 North High St., Baltimore, Md., $715; W. E. Tuttle, Garwood, N. J., $632; Ward Leonard Electric Co., South St., Mt. Vernon, N. Y., $50 part bid; Hobart Bros., Troy, Ohio, $421.

D. C., Wash.—Bids were received by the Bureau of Supplies and Accounts, Navy Dept., for furnishing equipment as follows:
Schedule 5639¼, Class 139, one motor driven miller, one vertical milling attachment, and three 2 in. diam. arbors, from Fairbanks Co., Colorado Bldg., $1620; Kemp Machinery Co., 223 North Calvert St., Baltimore, Md., $678.

Ohio, Akron—City received low bids for the erection of a pumping station, 31 x 67 ft. in plan 16 ft. high, involving 300 cu.yd. of concrete masonry in superstructure and machinery foundation; from Alger & Krans Co., 701 Guardian Bldg., $38,570, and F. E. McShaffrey, South Forge St., $50,780.

Ohio, Cleveland—City received low bid for the erection of a 1- and 2-story, 63 x 120 ft. boiler house at Willow Station, from Kelly Demarest, American Trust Bldg., $62,192.

Col., Brighton—City has awarded the contract for the erection of a new power house to E. B. Jones. Estimated cost, $16,922.

Ill., Kincaid—The Railway and Mining Supply Co. is in the market for four 25 in. upright power-feed belt-driven drills, with tapping attachment.

Ohio, Cincinnati—The Le Blond Machine Tool Co., Eastern Ave., will install a steam heating system in the proposed 2-story, tool factory. Total estimated cost, $50,000. G. Drack, Union Trust Bldg., Engr.

Ohio, Cleveland—The Board of Education has awarded the contract for the erection of a 1- and 2-story, 40 x 123 and 30 x 52 ft. machine shop on East 55th St., to C. A. Carson, 6804 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $50,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$5.50	$6.25	Broken	$6.75	$7.50
Buck.	5.10	5.90	Egg	6.65	7.40
Rice	4.65	5.10	Stove	6.90	7.65
Barley	4.15	4.30	Chestnut	7.00	7.75

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.75	$5.00	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.20		2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene, Shelby County	4.60	4.85	2.50